SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY, SURAT

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No: Dean (Acad.)/IAAC/707/2023-24 Date: 01/08/2024

The minutes of the 67th meeting of the Institute Academic Advisory Committee (IAAC)

The aforesaid meeting was held on 8th July 2024, 04:00 pm onwards in the Institute Conference room, first floor, Administrative Building. The following members attended the IAAC meeting.

	Chairman		
1	Prof. Anupam Shukla, Director		
	Members		
2	Dr. Pramod Mathur, Registrar	14	Prof. B.Z. Dholakiya, Head, DoC
3	Prof. C.D. Modhera, Dean (FW)	15	Dr. D. R. Roy, Head, DoP
4	Prof. J.K. Parikh, Dean (R&C)	16	Dr. J. M. Dhodiya, Head, DoMS
5	Prof. S.R. Patel, Dean (SW)	17	Dr. Urvashi Kaushal, Head, DoHSS
6	Prof. M. A. Desai, I/c. Head, DoCHE	18	Dr. R. K. Jana, Asso. Dean (Academic)
7	Prof. R. A. Christian, Head, DoCE	19	Prof. P. N. Patel, Asso. Dean (R&C)
8	Prof. M.A. Zaveri, Head, DoCSE	20	Dr. N. D. Jariwala, Asso. Dean (R&C)
9	Prof. Ritu Tiwari, Head, DoAI	21	Dr. M. K. Rathod, Asso. Dean (R&C)
10	Prof. P.B. Darji, Head, DoEE	22	Dr. S. N. Shah, Asso. Dean (SW)
11	Prof. J.N. Sarvaiya, Head, DoECE	23	Dr. R. K. Maurya, Asso. Dean (SW)
12	Prof. A.A. Shaikh, Head, DoME	24	Dr. Urvashi Kaushal, Head, DoHSS
13	Prof. K.P. Desai, Head, DoMS	25	Dr. R. K. Jana, Asso. Dean (Academic)
	Member Secretary		
26	Prof. Ravi Kant, Dean (Academic)		
	Invitees		
27	Prof. V.A. Shah (PI-UBA)	30	Dr. Y.A. Sonavane (NCC)
28	Prof. K.A. Chauhan	31	Rohit Raj (Student's General Secretary)
29	Dr. C.R. Patel	32	Bhupendra Pratap Singh (Acad. Affairs Secretary)

The following could not attend the meeting.

1	Prof. U.D. Dalal, Dean (A&RG)	6	Dr. Sushil Kumar, Assoc. Dean (FW)
2	Prof. S. S. Arkatkar, Dean (P&D)	7	Dr. B. Kondraivendhan, Asso. Dean (FW)
3	Prof. H. R. Jariwala, Assoc. Dean (Acad.)	8	Prof. H. K. Dave, Assoc. Dean (A&RG)
4	Dr. G. R. Vesmawala, Assoc. Dean (P&D)	9	Dr. H. P. Bulsara, Assoc. Dean (A&RG)
5	Prof. S. R. Arya, Assoc. Dean (P&D)		

At the outset, the Chairman IAAC warmly welcomed newly elected student representatives Rohit Raj (General Secretary) and Bhupendra Pratap Singh (Academic Affairs Secretary (AAS). The General Secretary of the Student Council, Rohit Raj, expressed the concern regarding

1. Laboratory space is required for students in the Physics Department as the department is under maintenance.
2. Offering Institute Elective subjects like Data Science and Artificial Intelligence, which may be open to all the students at the B.Tech and M.Sc. Level.
3. Opening of the Institute library for the extended time on working days and Weekend/Holidays.

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The director expressed concern over the ongoing building maintenance work of the Department of Physics, Chemistry, and Mathematics. Dean (P&D) will send a letter to the concerned agency to expedite the work on priority. Dean (P & D) and HoD (DoP) will identify a suitable space for the other departments to shift the affected laboratories, if possible.

All the heads of departments may take the initiative to offer data science and artificial intelligence courses in their domain and include them in the elective pool.

The Institute library opens for an extended time on working days and Weekends during the examination. However, the opening of the Institute library for extended periods on working days and weekends/holidays shall be discussed with the Professor- In-Charge Institute library. The Institute will meet the staff requirements, if any, in consultation with the Professor-In-Charge Institute library so that the library may be opened for extended periods of working days and Weekends/Holidays.

<u>Items and Resolutions</u>

Item 67.1	To consider the Scheme & Curriculum of M.Tech. Programs run by the departments as per NEP 2020. 1) Department of Chemical Engineering 2) Department of Civil Engineering 3) Department of Computer Science & Engineering 4) Department of Electrical Engineering 5) Department of Electronics Engineering 6) Department of Mechanical Engineering
Reso. 67.1	**Resolved to recommend the proposal of the Department of Chemical Engineering, Department of Civil Engineering, Department of Computer Science & Engineering, Department of Electronics Engineering, Department of Electrical Engineering, and Department of Mechanical Engineering to the Senate to approve the Scheme & Curriculum of M.Tech. Programs as per NEP 2020 (*<u>Annexure 67.1</u>*).** **Further, resolved to constitute a department-level committee of the concerned heads of departments to verify course outcomes, content, and recommended books. Also, the latest edition of the books needs to be updated in the recommended books section. The final Scheme & Curriculum need to be submitted to the Dean Academic office before the upcoming Senate.**
Item 67.2	To consider the Scheme of Five Years & Syllabus of First Year for Integrated B.Tech. + M.Tech.) program in Artificial Intelligence. [Ref: Department of the Artificial Intelligence; Reso. No.1, DAAC meeting, April 5, 2024]
Reso. 67.2	**Resolved to recommend the proposal of Department of Artificial Intelligence to the Senate to approve the Scheme of Five Years & Syllabus of the First Year for the Integrated (B.Tech. + M.Tech.) program in Artificial Intelligence (*<u>Annexure 67.2</u>*).**
Item 67.3	To finalize the "Mission and Vision" statements of the Department of Artificial Intelligence. [Ref: Department of the Artificial Intelligence; Reso. No.1, DAAC meeting, June 27, 2024]
Reso. 67.3	**Resolved to recommend the proposal of Department of Artificial Intelligence to the Senate to approve the Mission and Vision statements of the Department of Artificial Intelligence. The Mission and Vision statements are as follows.** **Vision** Global excellence in fostering ethical Artificial Intelligence innovation for social good.

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	Mission	:	**a) To Impact Quality and Value-Based Technical Education with fundamentals in the field of Artificial Intelligence.**
		:	**b) To provide rigorous and interdisciplinary education program.**
		:	**c) To integrate ethical consideration into Artificial Intelligence research development and deployment practices.**
		:	**d) Collaborate with industry and to encourage entrepreneurship skills to apply Artificial Intelligence innovation in real world scenarios.**
Item 67.4	To consider the scheme and syllabus for the two proposed M.Tech. Programs in Data Science & Business Intelligence and Artificial Intelligence and Machine Learning starting from the next academic year 2025-26, with a student intake of 30 each. [Ref: Department of the Artificial Intelligence; Reso. No. 3 and 5, DAAC meeting, June 27, 2024]		
Reso. 67.4	**Resolved to recommend the proposal of Department of Artificial Intelligence to the Senate to approve the scheme and syllabus for M.Tech in Artificial Intelligence and Machine Learning *(Annexure 67.4)* starting from the next academic year 2025-26, with a student intake of 30 each.** **Further, resolved to recommend to the Senate that current M.Tech Programme on Data Science, run by the Department of Computer Science and Engineering, will be run by the Department of Artificial Intelligence starting from the academic year 2026-27.**		
Item 67.5	To consider the request of the category conversion from FIR to ERS for Rushikesh Ashokbhai Prajapati (DS18CH003), a Ph.D. student working under the supervision of Dr. G.C. Jadeja, with effect from February 28, 2024. [Ref: Department of the Chemical Engineering; Reso. No. 2, 113th DAAC meeting, March 8, 2024]		
Reso. 67.5	**Resolved to recommend the proposal of the Department of Chemical Engineering to the Senate to consider the request of the category conversion from FIR to ERS for Rushikesh Ashokbhai Prajapati (DS18CH003), a Ph.D. student working under the supervision of Dr. G.C. Jadeja, with effect from February 28, 2024.** [Ref: 6.5.6 (d) 3, Academic Regulation 2023-24 & Reso. 9, 58th Senate meeting, May, 31 2023]		
Item 67.6	To consider the new proposed core elective subject, Catalyst Science and Technology in B.Tech, Chemical Engineering, 4th Year, 7th semester and elective subject, Advanced Materials and Advanced Process in M.Tech- Chemical Engineering, 1st Year, 1st Semester. [Ref: Department of the Chemical Engineering; Reso. No. 3, 114th DAAC meeting, April 09, 2024]		
Reso. 67.6	**Resolved to recommend the proposal of Department of Chemical Engineering to the Senate to consider the new core elective subject, Catalyst Science and Technology in B.Tech, Chemical Engineering, 4th Year, 7th semester and elective subject, Advanced Materials and Advanced Process in M.Tech- Chemical Engineering, 1st Year, 1st Semester *(Annexure 67.6)*.**		

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Item 67.7 To change the subjects of Petrochemical Technology (CH364) and Petroleum Refinery Engineering (CH366) of B.Tech, Chemical Engineering, 3rd Year, 6th Semester from Open Elective to Core Elective.

[Ref: Department of the Chemical Engineering; Reso. No. 4, 114th DAAC meeting, April 09, 2024]

Reso. 67.7 **Resolved to recommend the proposal of the Department of Chemical Engineering to the Senate to consider the change in the subjects of Petrochemical Technology (CH364) and Petroleum Refinery Engineering (CH366) of B.Tech, Chemical Engineering, 3rd Year, 6th Semester from Open Elective to Core Elective (*<u>Annexure 67.7</u>*).**

Item 67.8 To consider the request of the category conversion from FIR to ERS for the following students.

Parsai Ganesh Subhashbhai	D19CH003	FIR to ERS	Dr. J.K. Parikh
Bansod Shama Parashar	D19CH004	FIR to ERS	Dr. J.K. Parikh
Megha Vichare	D19CH005	FIR to ERS	Dr. A.K. Jana
Chhatbar Monali Mahendrabhai	D18CH006	FIR to ERS	Dr. A. K. Mungray

[Ref: Department of the Chemical Engineering; Reso. No. 2, 116th DAAC meeting, May 09, 2024]

Reso. 67.8 **Resolved to recommend the proposal of Department of Chemical Engineering to the Senate to consider the request of the category conversion of the following students with effect mentioned below.**

Name of Students	**Category Conversion**	**Effective date**
Parsai Ganesh Subhashbhai (D19CH003)	**FIR to ERS**	**After completion of 5 years**
Bansod Shama Parashar (D19CH004)	**FIR to ERS**	**After completion of 5 years**
Megha Vichare (D19CH005)	**FIR to ERS**	**After completion of 5 years**
Chhatbar Monali Mahendrabhai (D18CH006)	**FIR to ERS**	**27.06.2024**

Further, resolved to recommend to the senate that Ph.D. students admitted before the academic Year 2023-24 will be governed by the academic regulation for the doctoral programs- July 2019 onwards (including admitted previously unless specified for a particular clause).

Further, resolved to recommend to the senate that clause 6.5.6 and Reso. 9 of the 58th meeting held on May 31, 2023 regarding the PhD Candidate Category Change will be applicable to all the students irrespective of their admission year.

[Ref: 6.5.6 (d) 3, Academic Regulation 2023-24 & Reso. 9, 58th Senate meeting, May, 31 2023]

Item 67.9 To consider the request to extend the Ph.D. thesis submission up to June 30, 2024 for Neha S. Baghele (DS18CE003), a Ph.D. student working under the supervision of Prof. R.A. Christian.

[Ref: Department of the Civil Engineering; Reso. No. 63.4, 63rd DAAC meeting, January 30, 2024]

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Reso. 67.9	Neha S. Baghele had submitted synopsis on August 24, 2023. She was on maternity leave. **Resolved to recommend the proposal of the Department of Civil Engineering to the Senate as a special case to extend the Ph.D. thesis submission up to June 30, 2024 for Neha S Baghele (DS18CE003), a Ph.D. student working under the supervision of Prof. R.A. Christian.**
Item 67.10	To consider the request from the Environmental Engineering Section to change the Course Code of at B.Tech, Civil Engineering, 2nd Year; 4th Semester (Applicable for Batch 2021-24 Model: 2 Only) as mentioned below. Name of Subject: Environmental Engineering II; Current Course Code: CE303; Proposed Course Code: CE202 [Ref: Department of the Civil Engineering; Reso. No. 63.5, 63rd DAAC meeting, January 30, 2024]
Reso. 67.10	**Resolved to recommend the proposal of the Department of Civil Engineering to the Senate to change the Course Code of at B.Tech, Civil Engineering, 2nd Year; 4th Semester (applicable for Batch 2021-24 Model:2 Only).**
Item 67.11	To consider the syllabus of following Vocational Training for the B.Tech Civil Engineering students. a) CEV106 Vocational training for Surveyor b) CEV108 Vocational training for Construction Site supervisor [Ref: Department of the Civil Engineering; Reso. No. 63.7, 63rd DAAC meeting, January 30, 2024]
Reso. 67.11	**Resolved to recommend the proposal of the Department of Civil Engineering to the Senate regarding the syllabus of Vocational training for Surveyor (CEV 106) and Vocational training for Construction Site supervisor (CEV 108) for the B.Tech Civil Engineering students *(Annexure 67.11)*.**
Item 67.12	To consider the request from the TEP section for permission to continue to pursue a Master's Thesis at an Industry/Research Lab./ Field Organization / Academic Institution with a stipend from SVNIT, Surat. [Ref: Department of the Civil Engineering; Reso. No. 63.10, 63rd DAAC meeting, January 30, 2024]
Reso. 67.12	Dean (Academic) informed the house that a similar matter was placed before the 65th IAAC held on January 02, 2024, and recommended to the Senate (Item and Reso. 65.18) regarding the M.Tech Dissertation at the IITs/other NITs/ National Laboratories like ISRO, CSIR, etc. It was resolved that no financial support should be provided to the students for the dissertation work at the IITs/other NITs/ National Laboratories like ISRO, CSIR, etc. Further, it was approved in the 60th Senate meeting held on January 23, 2024. The members were of the opinion that academic collaborations with reputed institutions and Industries are significant. Students should be able to work with premier institutions and industries to gain exposure to reputed institutions and industries. On the other hand, Institute laboratories need to be utilized effectively and students should work in the Institute laboratories. After deliberations, it was; **Resolved to recommend to the Senate to allow the M.Tech GATE qualified students of all the Engineering Disciplines for Two (02) Months for the Internship/ experimentation and data collection for the dissertation work at the**

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	Industry/Research Laboratories/ Field Organization / Academic Institution with stipend. **Further, resolved that their stipend will be released based on the submission of the attendance certified by the authorized person at the Industry/Research Laboratories/ Field Organization / Academic Institution and duly countersigned by the PG-In-Charge/ Supervisor and concerned Head of Departments.**
Item 67.13	To consider and approve the Standard Operating Procedure (SOP), Evaluation pattern, and Rubrics for the CE402 Industrial Internship for the B.Tech, Civil Engineering, 4th Year, 8th Semester students. [Ref: Department of the Civil Engineering; Reso. No. 63.13, 63rd DAAC meeting, January 30, 2024]
Reso. 67.13	**Resolved to recommend the proposal of the Department of Civil Engineering to the Senate to approve the Standard Operating Procedure (SOP), Evaluation pattern, and Rubrics for the CE402 Industrial Internship for the B.Tech, Civil Engineering, 4th Year, 8th Semester students *(Annexure 67.13)*.**
Item 67.14	To consider the request of the Head of the Department of Humanities and Social Sciences to shift the HS 110-English and Professional Communication and HS 120- Indian Value System and Social Consciousness from its current semesters. [Ref: Department of the Civil Engineering; Reso. No. 66.4, 66th DAAC meeting, May 17, 2024]
Reso. 67.14	**Resolved to recommend the proposal of the Department of Civil Engineering to the Senate to consider the request of the Head of the Department of Humanities and Social Sciences to shift the subjects as given below with effect from the Academic Year 2024-25.**

Name of Subject	Current Semester	Proposed Semester
HS 110-English and Professional Communication	1st Sem.	2nd Sem.
HS 120- Indian Value System and Social Consciousness	2nd Sem.	1st Sem.

	Accordingly, the course code will also be revised by the concern department. Further, department will update the information on the Institute Website.
Item 67.15	To consider the request of the category conversion from FIR to ERS for Akshay Chauhan (D19CE01), a Ph.D. student working under the supervision of Dr. N. D. Jariwala, with effect from May 02, 2024. [Ref: Department of the Civil Engineering; Reso. No. 66.5, 66th DAAC meeting, May 17, 2024]
Reso. 67.15	Akshay Chauhan (D19CE01) has submitted the No objection certificate. **Resolved to recommend the proposal of the Department of Civil Engineering to the Senate to consider the request of the category conversion from FIR to ERS for Akshay Chauhan (D19CE01), a Ph.D. student working under the supervision of Dr. N. D. Jariwala, with effect from May 02, 2024.** [Ref: 6.5.6 (d) 3, Academic Regulation 2023-24 & Reso. 9, 58th Senate meeting, May, 31 2023]

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<tr><td>Item 67.16</td><td>To consider the recommendation of the DAAC to change Dr. P.L. Patel from the main supervisor to co-supervisor due to his appointment as the Director of VNIT Nagpur and the addition of the Main Supervisor as below for the following students.
<table>
<tr><th>Students' Name</th><th>Reg. No.</th><th>Existing Supervisor</th><th>Proposed Supervisor</th></tr>
<tr><td>Banwari Lal Meena (PEC)</td><td>D19CE005</td><td>Dr. P.L. Patel</td><td>Dr. P.V. Timbadiya
Dr. P.L. Patel</td></tr>
<tr><td>Sudhanshu Dixit (PEC)</td><td>DS20CE010</td><td>Dr. P.L. Patel</td><td>Dr. P.V. Timbadiya
Dr. P.L. Patel</td></tr>
<tr><td>Rajput Sandipkumar Vidhyasagar (FIR)</td><td>DS22CE004</td><td>Dr. P.L. Patel</td><td>Dr. P.V. Timbadiya
Dr. P.L. Patel</td></tr>
<tr><td>Anant Kumar Nagar (FIR)</td><td>D23CE010</td><td>Dr. P.L. Patel</td><td>Dr. P.V. Timbadiya
Dr. P.L. Patel</td></tr>
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[Ref: Department of the Civil Engineering; Reso. No. 66.6, 66th DAAC meeting, May 17, 2024]</td></tr>
<tr><td>Reso. 67.16</td><td>The total number of FIR working under Dr. P.V. Timbadiya is 4.5 which is more than the permissible limit of 04.
Resolved to recommend the proposal of the Department of Civil Engineering to the Senate to consider the change of Prof. P.L. Patel from the main supervisor to co-supervisor due to his appointment as the Director of VNIT Nagpur and the addition of the Main Supervisor as Dr. P.V. Timbadiya for the students Banwari Lal Meena (D19CE005)-PEC and Sudhanshu Dixit (DS20CE010)-PEC.

Further, resolved to refer back the proposal of the Department of Civil Engineering regarding the change of Prof. P.L. Patel from the main supervisor to co-supervisor for the Rajput Sandipkumar Vidhyasagar (DS22CE004)-FIR and Anant Kumar Nagar (D23CE010) and the addition of the Main Supervisor as Dr. P.V. Timbadiya as Dr. P.V. Timbadiya exceeds the maximum limit of the FIR category permitted to a faculty.</td></tr>
<tr><td>Item 67.17</td><td>To consider the request received from the WRE section regarding the qualifying degree with GATE paper mapping matrix for M.Tech in Water Resource Engineering.
[Ref: Department of the Civil Engineering; Reso. No. 66.10, 66th DAAC meeting, May 17, 2024]</td></tr>
<tr><td>Reso. 67.17</td><td>Resolved to recommend the proposal of the Department of Civil Engineering to the Senate regarding the qualifying degree with GATE paper mapping matrix for M.Tech in Water Resource Engineering (Annexure 67.17).</td></tr>
<tr><td>Item 67.18</td><td>To consider the request of the category conversion from FIR to PEC for Hrutvik Sharma (D20CE008), a Ph.D. student working under the supervision of Dr. Ravin Tailor, with effect from May 20, 2024.
[Ref: Department of the Civil Engineering; Reso. No. 68.1, 68th DAAC meeting, June 24, 2024]</td></tr>
<tr><td>Reso. 67.18</td><td>Hrutvik Sharma had submitted the No objection Certificate.

Resolved to recommend the proposal of the Department of Civil Engineering to the Senate to consider the request of the category conversion from FIR to ERS for Hrutvik Sharma (D20CE008), a Ph.D. student working under the supervision of Dr. Ravin Tailor, with effect from May 20, 2024.

[Ref: 6.5.6 (d) 3, Academic Regulation 2023-24 & Reso. 9, 58th Senate meeting, May, 31 2023]</td></tr>
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Item 67.19	To consider the request of the category conversion from FIR to PEC for Vivek Champaneria (D19CO004), a Ph.D. student working under the supervision of Prof. M.A. Zaveri and Dr. S.J. Patel, with effect from July 02, 2024. [Ref: Department of Computer Science and Engineering; Reso. No. 2, DAAC meeting, July 02, 2024]
Reso. 67.19	**Resolved to recommend the proposal of the Department of Computer Science and Engineering to the Senate to consider the request of the category conversion from FIR to ERS for Vivek Champaneria (D19CO004), a Ph.D. student working under the supervision of Prof. M.A. Zaveri and Dr. S.J. Patel, with effect from July 02, 2024.** [Ref: 6.5.6 (d) 3, Academic Regulation 2023-24 & Reso. 9, 58th Senate meeting, May, 31 2023]
Item 67.20	Regarding MOOC-I and MOOC-II courses to be offered to M.Tech II year 3rd Semester students from NPTEL/ SWAYM for all M.Tech programme. [Ref: Department of Computer Science and Engineering; Reso. No. 1, DAAC meeting, July 05, 2024]
Reso. 67.20	**Resolved to recommend the proposal of the Department of Computer Science and Engineering to the Senate to consider the MOOC-I and MOOC-II courses to be offered to M.Tech, 2nd Year students in their 3rd Semester from NPTEL/ SWAYM for the academic year 2024-25 *(Annexure 67.20)* .**
Item 67.21	To consider the request to extend the thesis submission for one year to Shivani Vasantbhai Vora (D17CO002), a Ph.D. student working under the supervision of Prof R.G. Mehta. [Ref: Department of Computer Science and Engineering; Reso. No. 3, DAAC meeting, July 05, 2024]
Reso. 67.21	Shivani Vasantbhai Vora had published one Journal Paper and 02 Journal papers are under the review. **Resolved to recommend the proposal of the Department of Computer Science and Engineering to the Senate to consider the extension of the Ph.D. duration only for the Six Months to Shivani Vasantbhai Vora (D17CO002), a Ph.D. student working under the supervision of Prof R.G. Mehta.**
Item 67.22	To consider the request of the category conversion from FIR to ERS for Praful Pandurang Kumbhare (DS19EL001), a Ph.D. student working under the supervision of Dr. Sanjay Tolani, with effect from April 02, 2024. [Ref: Department of Electrical Engineering; Reso. No. 1, 76th DAAC meeting, May 02, 2024]
Reso. 67.22	Praful Pandurang Kumbhare had submitted the No objection Certificate. **Resolved to recommend the proposal of the Department of Electrical Engineering to the Senate to consider the request of the category conversion from FIR to ERS for Praful Pandurang Kumbhare (DS19EL001), a Ph.D. student working under the supervision of Dr. Sanjay Tolani, with effect from April 02, 2024.** [Ref: 6.5.6 (d) 3, Academic Regulation 2023-24 & Reso. 9, 58th Senate meeting, May, 31 2023]

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Item 67.23	To consider the request to extend the Ph.D. duration for six months to Kalindi Shinde (D17EC008), a Ph.D. student working under the supervision of Dr. S.N. Shah and Prof. P.N. Patel. (Reso. 1; 88th DAAC meeting held on July 04, 2024). [Ref: Department of Electronics Engineering; Reso. No. 1, 88th DAAC meeting, July 04, 2024]
Reso. 67.23	Kalindi Shinde had published One Journal Paper. In addition to that her One Journal paper is accepted and One Journal paper is under the review. **Resolved to recommend the proposal of the Department of Electronics Engineering to the Senate to consider the request to extend the Ph.D. duration for six months to Kalindi Shinde (D17EC008), a Ph.D. student working under the supervision of Dr. S.N. Shah and Prof. P.N. Patel.**
Item 67.24	To consider the request of the category conversion from FIR to PEC for Mitul Sudhir Kumar Nagar (D19EC005), a Ph.D. student working under the supervision of Dr. P.J. Engineer, with effect from June 14, 2024. [Ref: Department of Electronics Engineering; Reso. No. 2, 88th DAAC meeting, July 04, 2024]
Reso. 67.24	Mitul Sudhir Kumar Nagar had submitted the No objection Certificate. **Resolved to recommend the proposal of the Department of Electrical Engineering to the Senate to consider the request of the category conversion from FIR to ERS for Mitul Sudhir Kumar Nagar (D19EC005), a Ph.D. student working under the supervision of Dr. P.J. Engineer, with effect from June 14, 2024.** [Ref: 6.5.6 (d) 3, Academic Regulation 2023-24 & Reso. 9, 58th Senate meeting, May, 31 2023]
Item 67.25	To consider the request of the category conversion from FIR to ERS for Shyam Rangrej (D19ME004), a Ph.D. student working under the supervision of Dr. S.N. Pandya and Dr. J.V. Menghani. (Ref: Department of Mechanical Engineering, Reso. No. 74.7, 74th DAAC meeting, May 22, 2024)
Reso. 67.25	**Resolved to recommend the proposal of the Department of Mechanical Engineering to the Senate to consider the request of the category conversion from FIR to ERS for Shyam Rangrej (D19ME004), a Ph.D. student working under the supervision of Dr. S.N. Pandya and Dr. J.V. Menghani.** [Ref: 6.5.6(d)3; Academic Regulation 2023-24 & Reso.9; 58th Senate meeting, May, 31 2023)
Item 67.26	To consider a request of Ph.D. Student Awadhesh Yadav (D20ME017) enrolled in the FIR category to discontinue/relieve Dr. T.N. Desai, Professor, DoME, as his Ph.D. Co-supervisor due to his retirement. Dr. Ravi Kant, Professor, DoME will continue as Supervisor. (Ref: Department of Mechanical Engineering, Reso. 75.5; 75th DAAC meeting July 4, 2024)
Reso. 67.26	**Resolved to recommend the proposal of the Department of Mechanical Engineering to the Senate to consider the request to discontinue/relieve Dr. T.N. Desai, Professor, DoME, as Ph.D. Co-supervisor due to his retirement of Awadhesh Yadav (D20ME017). Dr. Ravi Kant will now act as a sole supervisor**.
Item 67.27	To consider the request to extend the thesis submission for 03 months to Mayank Shah (DS17ME004), a Ph.D. student working under the supervision of Dr. R.D. Shah. (Ref: Department of Mechanical Engineering; Reso. 75.6; 75th DAAC meeting July 4, 2024)

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Reso. 67.27	Mr Mayank Shah (DS17ME004) had submitted the synopsis on September 20, 2023. He was given six months extension for thesis submission up to 19th May 2024 vide Reso. 66.21, 66th meeting of the IAAC held on 20th March 2024. **Resolved to recommend the proposal of the Department of Mechanical Engineering to the Senate to extend the Ph.D. thesis submission for 3 months as a Special Case for Mayak Shah (DS17ME004), a Ph.D. student working under the supervision of Dr. R.D. Shah.**
Item 67.28	To consider the request of the category conversion for the following students.

Name of Students	Category Conversion	Admission Number	Supervisor	Effective date
Nisha Devanand Khotele	FIR to FRS	DS23PH004	Dr. D.R. Roy	29.12.2023
Vishwa Kamal Desai	FSF to FRS	D22PH011	Dr. D.R. Roy Dr. D.V. Shah	24.08.2022
Juhi Oudichhya	FIR to FRS	DS19PH002	Prof. A.K. Rai	01.03.2024

[Ref: Department of Physics; Reso. No.4; 49th DAAC meeting, March 03, 2024]

Reso. 67.28	**Resolved to recommend the proposal of Department of Physics to the Senate to consider the request of the category conversion of the following students.**

Name of Students	**Category Conversion**	**Effective date**
Nisha Devanand Khotele (DS23PH004)	**FIR to ERS**	**29.12.2023**
Vishwa Kamal Desai (D22PH011)	**FSF to ERS**	**24.08.2022**
Juhi Oudichhya (DS19PH002)	**FIR to ERS**	**01.03.2024**

[Ref: 6.5.6 (d) 3, Academic Regulation 2023-24 & Reso. 9, 58th Senate meeting, May, 31 2023]

Item 67.29	To finalize the "Mission and Vision" statements of the Department of Physics. [Ref: Department of Physics; Reso. No.2; 50th DAAC meeting, May 02, 2024].
Reso. 67.29	**Resolved to recommend the proposal of Department of Physics to the Senate to approve the Mission and Vision statements of the Department of Physics. The Mission and Vision statements are as follows.** **Vision** **The department visualizes itself to be a center of excellence of learning the Physical Sciences.** **Mission** : **The department endeavors to achieve its goals through introduction of innovative and intellectually challenging courses.** : **It vows to undertake to strengthen its presence in technological programs offered by the institute to benefit the society.**
Item 67.30	To consider the pool of Minor degree courses in the B.Tech. in Engineering Physics curriculum. [Ref: Department of Physics; Res. No. 1; 52nd DAAC meeting, July 03, 2024].
Reso. 67.30	**Resolved to recommend the proposal of Department of Physics to the Senate to approve the pool of Minor degree courses in the B.Tech. in Engineering Physics curriculum applicable to the students admitted with effect from academic year 2024-25 (*<u>Annexure 67.30</u>*).**

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Item 67.31 To consider and approve the syllabus of the following Vocational Training courses for the 5-Year integrated M.Sc. (Physics) with effect from academic year 2023-24.

Sr. No.	Course Code	Course Name	Semester
1.	PHV02	Linux and Shell Programming	II
2.	PHV03	Solar Panel Assembling, Testing and Installations	III
3.	PHV04	Automation of Scientific Experiments by Virtual Instrumentation using Lab VIEW	IV

[Ref: Department of Physics; Res. No.2; 52nd DAAC meeting, July 03, 2024].

Reso. 67.31 **Resolved to recommend the proposal of Department of Physics to the Senate to approve the syllabus of the following Vocational Training courses Linux and Shell Programming (PHV02)- 2nd Semester, Solar Panel Assembling, Testing and Installations (PHV03)-3rd Semester, Automation of Scientific Experiments by Virtual Instrumentation using Lab VIEW (PHV04) -4th Semester -for 5-Year integrated M.Sc. in Physics. These courses will be applicable to the students admitted in the academic year 2023-24 onwards *(Annexure 67.31)*.**

Item 67.32 To consider the request of the category conversion from FPS to FIR for Divya (DS22CY005), a Ph.D. student working under the supervision of Dr. Ritambhara Jangir and Dr. Sarita Kalla, with effect from May 1, 2024.

[Ref: Department of Chemistry; Reso. 2; 128th DAAC meeting, May 10, 2024]

Reso. 67.32 **Resolved to recommend the proposal of the Department of Chemistry to the Senate to consider the request of the category conversion from FPS to FIR for Divya (DS22CY005), a Ph.D. student working under the supervision of Ritambhara Jangir and Dr. Sarita Kalla, with effect from May 1, 2024.**

[Ref: 6.5.6(e); Academic Regulation 2023-24 & Reso.9; 58th Senate meeting, May, 31 2023]

Item 67.33 To consider the recommendation of the DAAC to change the supervisor for the following Ph.D. students

Students' Name	Reg. No.	Existing Supervisor	Proposed Supervisor
Sudha Soliya (FIR)	D22CY003	Dr. Naveen Togati Dr. Ketan Kuperkar	Dr. Areti Sivaiah
Piyushkumar Satani (FIR)	DS22CY022	Dr. Naveen Togati	Dr. Subrata Dutta

[Ref: Department of Chemistry; Reso. 2; 129th DAAC meeting held on May 15, 2024].

Reso. 67.33 **Resolved to recommend the proposal of the Department of Chemistry to the Senate to consider a request to change the supervisor with effect from date of approval of Senate for Sudha Soliya (D22CY003) and Piyushkumar Satani (DS22CY022). The details are as follows:**

Students' Name	Proposed Supervisor
Sudha Soliya (D22CY003)	**Dr. Areti Sivaiah**
Piyushkumar Satani (DS22CY022)	**Dr. Subrata Dutta**

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Item 67.34	To consider the request to extend the thesis submission for 08 months to Meenakshi B. Paswan (D18CY005), a Ph.D. student working under the supervision of Prof B. Z. Dholakiya due to her medical conditions. [Ref: Department of Chemistry; Reso. 2; 130th DAAC meeting, May 20, 2024].
Reso. 67.34	Meenakshi B. Paswan had submitted synopsis on November 30, 2023. **Resolved to recommend the proposal of the Department of Chemistry to the Senate to extend the Ph.D. thesis submission for 08 months to Meenakshi B. Paswan (D18CY005), a Ph.D. student working under the supervision of Prof. B.Z. Dholakiya due to the medical condition as a *Special Case*** [Ref: 6.5.6 (d) 3, Academic Regulation 2023-24 & Reso. 9, 58th Senate meeting, May, 31 2023]
Item 67.35	To consider the proposal for the Establishment a Digital Language Lab. [Ref: Department of Humanities & Social Sciences; Reso. 4.2; 4th DAAC meeting, April 16, 2024].
Reso. 67.35	**Resolved to recommend the proposal of the Department of Humanities & Social Sciences to the Senate to consider the proposal for the Establishment a Digital Language Lab *(Annexure 67.35)*.**
Item 67.36	To consider the proposal for the Establishment of a Centre for Rural Technology Development [Ref: Department of Humanities & Social Sciences; Reso. 5.2; 5th DAAC meeting, May 22, 2024].
Reso. 67.36	The Department of Humanities and Social Sciences proposes to establish a Centre for Tribal Development and Technology (CoTDT) at SVNIT Surat is supported by several compelling reasons. Firstly, it reflects SVNIT's acknowledgment of its socio-academic responsibility towards the surrounding tribal communities, who often face marginalization and limited opportunities. Secondly, it aligns with the institute's mission to use its academic and technical resources for the betterment of society. Thirdly, it draws inspiration from the successful models of community development and technology integration implemented by other Institutes of National Importance, which have demonstrated significant positive impacts on rural and tribal populations. The objectives of CoTDT includes the community empowerment, technology adoption, research and innovation and collaborative partnerships. CoTDT may engage in a variety of activities, but not limited to skill development workshops, educational outreach programs, technology, showcases research projects and community engagement initiatives. After deliberations, it was; **Resolved to recommend the proposal of the Department of Humanities & Social Sciences to the Senate to consider the proposal for the Establishment of a Centre for Rural Technology Development *(Annexure 67.36)*.**
Item 67.37	To consider the proposal of Dr Yogesh A. Sonwane, NCC Officer for adding NCC as an additional / extra elective course in B.Tech and M.Sc students with effect from the Academic Year 2024-25.

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Reso. 67.37	Directorate General NCC has proposed NCC as a general elective subject for the India University/Institute. Lt. (Dr.) Yogesh Sonavane will take the courses along with the PI staff recommended by the NCC unit. Lecture, tutorals and Practicles will be taken only on the Saturday, Sunday and holidays. After deliberations, it was; **Resolved to recommend to the Senate to consider the proposal of Dr Yogesh A. Sonwane, NCC Officer for adding NCC as an *optional* additional / extra elective course for B.Tech and M.Sc students with effect from the Academic Year 2024-25 (*Annexure 67.37*).** **The maximum allowable strength for each semester will be 60. The entire activity of this courses will be conducted on the weekends/vacations. The load of faculty involved in this activity will not be considered as the teaching load. Dr Yogesh A. Sonwane, NCC Officer will be responsible for the entry of marks. The separate marksheet will be provided for the students on the completion of this course at the end of their 6th Semester.**
Item 67.38	To consider the proposal of Prof. Varsha A Shah, Chairperson, PI-Unnat Bharat Abyiyan (UBA), Surat to introduce Community Engagement and Social Responsibility as an additional optional field activity of 30 Hours in a Semester for the First and Second Year of B.Tech and M.Sc students from the Academic Year 2024-25.
Reso. 67.38	The Community Engagement and Social Responsibility course aims to equip students with a deeper understanding of rural realities and a sense of social responsibility. This initiative addresses the growing disconnect between urbanized students and the rural comminates, a significant portion of the country's population. By integrating community engagement into education, UBA 2.0 hopes to foster a more well-rounded educational experience while contributing to rural India's social and economic development. After deliberations, it was; **Resolved to recommend to the Senate to consider the proposal of Prof. Varsha A Shah, Chairperson, PI-Unnat Bharat Abyiyan (UBA), Surat to introduce Community Engagement and Social Responsibility as an additional Optional field activity of 30 Hours in a Semester for the First and Second Year of B.Tech and M.Sc students from the Academic Year 2024-25. Chairperson, PI-Unnat Bharat Abyiyan (UBA), Surat will decide the evaluation pattern and inform to the Dean (Academic). (*Annexure 67.38*).** **The course code for the Community Engagement and Social Responsibility will be from the Department of the Humanity and Social Sciences. Chairperson, PI-Unnat Bharat Abyiyan (UBA), Surat will appoint the one coordinator for the course and inform to the Dean (Academic).** **The maximum allowable strength for each semester will be 100. The entire activity of this courses will be conducted on the weekends/vacations. The load of faculty involved in this activity will not be considered as the teaching load. The course coordinator will be responsible for the entry of marks. The course will be floated in May/June and October/November for the respective autumn and Spring Semesters. The separate marksheet will be provided for the students on the completion of this course.**

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Item 67.39	Special provisions for persons with Disabilities in the examination.
Reso. 67.39	**Resolved to recommend to the Senate regarding Special provisions for persons with Disabilities in the examination *<u>(Annexure 67.39).</u>*** **Further, recommended to the Senate to empower the DAAC of the concern department to take a suitable decision for the special provisions for persons with Disabilities in the examination based on the level of disability.** [Ref: AICTE Guidelines for Inclusive education for all including persons with disability]
Item from Chair	
Item 67.40	To consider the request of the category conversion from FIR to ERS for Soniya Thacker (D23MA004), a Ph.D. student working under the supervision of Prof. A.K. Shukla, with effect from date of approval of Senate. [Ref: Department of Mathematics; 7th DAAC meeting, June 06, 2024].
Reso. 67.40	She has qualified UGC-CSIR NET examination (December 2023) and will get the scholarship from CSIR. **Resolved to recommend the proposal of Department of Mathematics to the Senate to consider the request of the category conversion from FIR to ERS for Soniya Thacker (D23MA004), a Ph.D. student working under the supervision of Prof. A.K. Shukla, with effect from date of approval of Senate.** [Ref: 6.5.6 (d) 3, Academic Regulation 2023-24 & Reso. 9, 58th Senate meeting, May, 31 2023]
Item 67.41	To consider the academic Calendar for First year of B. Tech. & M. Sc. and First Year of M. Tech. & Ph.D.
Reso. 67.41	**Resolved to recommend to the Senate to approve Academic Calendar for First year B. Tech. & M. Sc. and First Year of M. Tech. & Ph.D *<u>(Annexure 67.41a & Annexure 67.41b)</u>***
Item 67.42	To consider the proposal of Dr. K.A. Chauhan, Professor, Urban Panning Section, DoCE Establishment of 'AMRUT Funded Centres of Urban Planning for Capacity Building' by the Ministry of Housing and Urban Development, Government of India for developing capacities in urban planning and to deliver certified training in these areas.
Reso. 67.42	**Resolved to recommend to the Senate to consider the proposal of Dr. K.A. Chauhan, Professor, Urban Panning Section, DoCE Establishment of 'AMRUT Funded Centres of Urban Planning for Capacity Building' by the Ministry of Housing and Urban Development, Government of India for developing capacities in urban planning and to deliver certified training in these areas *<u>(Annexure 67.42)</u>*.** **Further, resolved to recommend to the Senate as follows:** **(i) The Centre In-Charge in consultation with the Head of Department will appoint a committee to monitor the implementation of the project with explicit roles and responsibilities of its members for execution of the activities to be undertaken including the funds for carrying out the activity of the centre.** **(ii) The Centre In-Charge will ensure the action plan indicating areas of expertise, subject-wise capacity building programmes proposed to be conducted and identify at least 2 cities in a state/ states and specific projects catering to the challenges and issues of the Cities to be undertaken in the first year.**

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Item 67.43	To introduce the minor degree courses, Institute Electives and Ph.D. program under the Centre of the Indian Knowledge System and Holistic Education.
Reso. 67.43	The Centre of the Indian Knowledge System and Holistic Education (CoIKSHE) was approved by the BOG Reso. No. 72.04.10.6 in its 72nd meeting held on February 15, 2024. The Indian Knowledge Systems comprise of Jnan, Vignan, and Jeevan Darshan that have evolved out of experience, observation, experimentation, and rigorous analysis. CoIKSHE will take the effort to the preserve and promote traditional knowledge, integration with modern education, research and development, cultural enrichment, holistic education interdisciplinary learning and community engagement. After deliberations, it was; **Resolved to recommend to the senate to consider the proposal to offer the minor degree courses, Institute Electives and Ph.D. program under the Centre of the Indian Knowledge System and Holistic Education. The course code will be similar to the UG and PG courses starting with IKS.** **Interested faculty from the different departments may contribute to CoIKSHE by floating the courses and guiding the Ph.D. students in the area of Indian Knowledge System and Holistic Education.**

रवि कां० 01.08.2024
Member-Secretary, IAAC

01/08/24.
Director

Annexure 67.1
of 67th meeting of the IAAC

SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY

DEPARTMENT OF CHEMICAL ENGINEERING

M. TECH. IN CHEMICAL ENGINEERING
2024-25

SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY
ICHHANATH, SURAT – 395007, GUJARAT.

VISION & MISSION

INSTITUTE VISION

To be one of the leading Technical Institutes disseminating globally acceptable education, effective industrial training and relevant research output.

DEPARTMENT VISION

In-line with the vision of the institute, to be a well reputed department with global acceptance and to produce highly skilled and knowledgeable chemical engineering graduates, post graduates and doctorates capable of delivering the best output to the society.

INSTITUTE MISSION

To be a globally accepted centre of excellence in technical education catalyzing absorption, innovation, diffusion and transfer of high technologies resulting in enhanced quality for all the stake holders.

DEPARTMENT MISSION

To be one of the top engineering departments with excellent research work in the fields related to Chemical Engineering and offering technical knowhow to the stake holders.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO 1: Have successful career in the diversified areas of chemical engineering (Research & Development, Academic and Industry) by acquiring knowledge in various advances of chemical engineering at global Level.

PEO 2: Analyze and design contemporary chemical engineering issues with socio-economic and environmental awareness and responsibility.

PEO 3: Exhibit professional approach, communication skills, team work in their profession and adapt to modern trends by engaging in lifelong learning.

PROGRAM OUTCOMES (POs)

PO 1: An ability to independently carry out research / investigation and development work to solve practical problems.

PO 2: An ability to write and present a substantial technical report / document.

PO 3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO 1: Recognize global challenges for solving engineering prolems related to chemical and allied fields through design and development of chemical processes.

PSO 2: Propose, investigate and evaluate sustainable solutions for chemical processes/products with socio-economical and environmental awareness alongwith professional ethics.

Teaching Scheme
M.Tech. in Chemical Engineering

Sr. No.	Subject	Code	Scheme L-T-P	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
				Th. Marks	T Marks	P Marks		
	First Semester							
1	Optimization Techniques (Core - 1)	CHCH101	3-1-0	100	25	-	4	70
2	Advanced Chemical Engineering Thermodynamics (Core – 2)	CHCH103	3-1-0	100	25	-	4	70
3	Advanced Transport Phenomena (Core – 3)	CHCH105	3-1-0	100	25	-	4	70
4	Elective-1	CHCH1AA	3-0-0	100	-	-	3	55
5	Elective-2	CHCH1BB	3-0-0	100	-	-	3	55
6	Chemical Engineering Lab-1	CHCH107	0-0-4	-	-	100	2	70
				Total			**20**	**390**
7	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	CHCHV91 CHCHP93	0-0-10				5	200 (20 x 10)
	Second Semester							
1	Advanced Chemical Reaction Engineering (Core - 4)	CHCH102	3-1-0	100	25	-	4	70
2	Advanced Separation Methods (Core - 5)	CHCH104	3-1-0	100	25	-	4	70
3	Elective-3	CHCH1CC	3-0-0	100	-	-	3	55
4	Elective-4	CHCH1DD	3-0-0	100	-	-	3	55
5	Institute Elective	CHCH1XX	3-0-0	100	-	-	3	55
6	Chemical Engineering Lab-2	CHCH106	0-0-4	-	-	100	2	70
7	Seminar	CHCH108	0-0-2	-	-	50	1	40
				Total			**20**	**415**
8	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	CHCHV92 CHCHP94	0-0-10				5	200 (20 x 10)
	Third Semester							
1	MOOC course – I*	#	#	#	#	#	3/4	70/80
2	MOOC course – II*	#	#	#	#	#	3/4	70/80
3	Dissertation Preliminaries	CHCH295	-	-	-	350$	14	560
				Total			**20-22**	**700-720**
	Fourth Semester							
1	Dissertation	CHCH296	-	-	-	600$	20	800

$ **Internal**: 40% and **External**: 60%
*Swayam/NPTEL

<u>List of Elective Courses</u>

Sr. No.	Elective Courses	Code	Semester	Scheme
1	Nanotechnology	CHCH111	I	3-0-0
2	Smart Polymers	CHCH113	I	3-0-0
3	Nanomaterials Synthesis and Applications	CHCH115	I	3-0-0
4	Interfacial Science and Engineering	CHCH117	I	3-0-0
5	Polymer Engineering	CHCH119	I	3-0-0
6	Process Intensification	CHCH121	I	3-0-0
7	Multiphase Flow	CHCH123	I	3-0-0
8	Advanced Materials and Processes	CHCH125	I	3-0-0
9	Complex Fluids	CHCH112	II	3-0-0
10	Industrial Biotechnology	CHCH114	II	3-0-0
11	Environment, Health and Safety	CHCH116	II	3-0-0
12	Computational Fluid Dynamics	CHCH118	II	3-0-0
13	Design of Experiments	CHCH120	II	3-0-0
14	Advanced Process Control	CHCH122	II	3-0-0
15	Catalyst Science and Technology	CHCH124	II	3-0-0
16	Sustainable Development Goals	CHCH126	II	3-0-0
17	Corrosion and Electrochemical Engineering*	CHCH172	II	3-0-0
18	Non-Conventional Energy*	CHCH174	II	3-0-0
19	Environment Management System*	CHCH176	II	3-0-0

*****Institute Elective

M. Tech. I (Chemical Engineering) – Semester - I OPTIMIZATION TECHNIQUES (CHCH101)	Scheme	L	T	P	Credit
		3	1	0	04

1.	**Course Outcomes (COs):** At the end of the course the students will be able to:
CO1	Relate the basic concept of optimization.
CO2	Formulate various process optimization problems.
CO3	Solve the chemical process optimization problems.
CO4	Relate the significance of numerical methods in linear and nonlinear programming.
CO5	Infer the application of optimization in chemical engineering.
CO6	Summarize the non-traditional optimization techniques and their applications.

2.	**Syllabus**	
	INTRODUCTION	**4 Hours**
	Scope and Hierarchy of Optimization, The essential Features of Optimization Problems, Maximization and minimization problems- examples, Basic concepts of optimization – Convex and concave functions, Necessary and sufficient conditions for stationary points, Degrees of freedom	
	MODELS FOR OPTIMIZATION	**4 Hours**
	Classifications of Models, How to build a Model fitting	
	FORMULATION	**4 Hours**
	Economic objective function, Formulation of various process optimization problems and their classification.	
	UNCONSTRAINED AND CONSTRAINED SEARCH	**9 Hours**
	Optimizing a function of one-variable, Unconstrained multivariable optimization, direct search methods, Indirect first order and second order methods, Constrained multivariable optimization - necessary and sufficient conditions for constrained optimum.	
	LINEAR PROGRAMMING AND APPLICATIONS	**8 Hours**
	Geometry of linear programs, Basic solution methods, Simplex algorithm and its applications. Sensitivity analysis	
	NON-LINEAR PROGRAMMING WITH CONSTRAINTS	**6 Hours**
	Quadratic programming, Generalized reduced gradients methods, Successive linear and successive quadratic programming, Dynamic programming, Integer and mixed integer programming	
	APPLICATION OF OPTIMIZATION IN CHEMICAL ENGINEERING	**6 Hours**
	Optimization of staged and discrete processes, Optimal heat exchanger design, Optimal pipe diameter, Optimal design of an Ammonia reactor	
	NONTRADITIONAL OPTIMIZATION TECHNIQUES	**4 Hours**
	Genetic Algorithm and Simulated Annealing	
	Tutorial problems based on the topics covered during the theory classes	**15 Hours**
	Total Contact Time: 45 Hours + 15 Hours = 60 Hours	

3.	**Books Recommended**
1	T. F. Edger, D. M. Himmelblau, "Optimization of Chemical Process", McGraw-Hill, New York, 2001. (Reprint).
2	S. S. Rao, "Engineering Optimization", New Age International, New Delhi, 2009.
3	K. Deb, "Optimization for Engineering Design: Algorithms and Examples," Prentice-Hall of India, Delhi, 2012.
4	N. W. Loney, "Applied Mathematical Methods for Chemical Engineers", CRS Press, Boca Raton, FL, 2015.
5	M. C. Joshi, K. M. Moudgalya, "Optimization: Theory and Practice", Alpha Science International Limited, Oxford, UK, 2004.

M. Tech. I (Chemical Engineering) – Semester - I ADANCED CHEMICAL ENGINEERING THERMODYNAMICS (CHCH103)	Scheme	L	T	P	Credit
		3	1	0	04

1.	**Course Outcomes (COs):** At the end of the course the students will be able to:
CO1	Describe intermolecular forces and relate to macroscopic thermodynamic properties.
CO2	Differentiate between ideal and non-ideal thermodynamic behaviour in both pure substances and mixtures.
CO3	Explain phase equilibria for multicomponent systems.
CO4	Estimate the thermodynamics properties of mixtures and solutions.
CO5	Evaluate and apply different methods/assumptions for performing phase equilibrium calculations,
CO6	Explain multi-reaction equilibria and solve problems.

2.	**Syllabus**	
	REVIEW OF CLASSICAL THERMODYNAMICS	**3 Hours**
	PROPERTIES OF PURE FLUIDS	**4 Hours**
	Thermo Properties from Volumetric Data, Equations of State, Generalized correlations.	
	INTERMOLECULAR INTERACTIONS AND CORRESPONDING STATE THEORY	**5 Hours**
	Origin of interactions (Permanent, induced and instantaneous dipoles), Intermolecular forces and potential energy functions, Corresponding states theory	
	THERMODYNAMIC PROPERTIES OF MIXTURES	**15 Hours**
	Mixtures, partial molar properties, Chemical potential, Gibbs Duhem equations, Property changes on mixing, Fugacity in gas mixtures-Virial and Cubic EOS, corresponding states, fugacities in liquid mixtures, fugacities in liquid mixtures (electrolyte solution) Excess Functions in Liquid Mixtures, Models for Excess Gibbs energy	
	PHASE EQUILIBRIA	**10 Hours**
	Multiphase Multicomponent phase equilibrium, VLE/SLE/LLE/VLLE, Solubility of gases in liquids, solubility of solids in liquids.	
	CHEMICAL EQUILIBRIUM	**6 Hours**
	Combined phase and Reaction equilibrium	
	INTRODUCTION TO MOLECULAR SIMULATION	**2 Hours**
	Tutorial problems based on the topics covered during the theory classes	**15 Hours**
	Total Contact Time: 45 Hours + 15 Hours = 60 Hours	

3.	**Books Recommended**
1	J.M. Prausnit, R.M. Lichtenthaler, E.G. Azevedo, “Molecular Thermodynamics of Fluid-Phase Equilibria”, 3rd edition, Prentice Hall Inc., 1999.
2	J.M. Smith. H.C. Van Ness, M.M.Abott, “Introduction to Chemical Engineering Thermodynamics”, 8th Edition, McGraw-Hill International edition, 2018.
3	S. I. Sandler, Chemical, Biochemical, and Engineering Thermodynamics, 5th Edition, John Wiley & Sons, Inc., 2017.
4	B. E. Poling, J. M. Prausnitz, J. P. O’Connell, “The Properties of Gases and Liquids”, 5th edition, McGraw-Hill, 2001.
5	J.W. Tester and M. Modell, “Thermodynamics and Its Applications”, 3rd Edition, Prentice Hall, 1997.

M. Tech. I (Chemical Engineering) – Semester - I ADVANCED TRANSPORT PHENOMENA (CHCH105)	Scheme	L	T	P	Credit
		3	1	0	04

1.	**Course Outcomes (COs):** At the end of the course the students will be able to:
CO1	Understand the chemical and physical transport processes and their mechanism
CO2	Perform heat, mass and momentum transfer analysis
CO3	Analyze industrial problems along with appropriate approximations and boundary conditions
CO4	Develop steady and time dependent solutions along with their limitations
CO5	Analyze various transport processes with understanding of solution approximation methods and their limitations.
CO6	Solve mass balance for steady and unsteady-state problems.

2.	**Syllabus**	
	INTRODUCTION	**1 Hour**
	TRANSPORT BY MOLECULAR MOTION	**12 Hours**
	Momentum transport by viscosity and momentum-flux. Energy transport by thermal conductivity and heat-flux. Mass transport by diffusivity and mass-flux.	
	TRANSPORT IN ONE DIMENSION (SHELL BALANCE METHODS)	**17 Hours**
	Shell momentum balances and velocity distributions. Shell energy balances and temperature distributions. Shell mass balances and concentration distributions.	
	USE OF GENERAL TRANSPORT EQUATIONS	**5 Hours**
	Equations of change and their use in momentum transport (isothermal). Equations of change and their use in energy transport (non-isothermal). Equations of change and their use in mass transport (mixtures).	
	TRANSPORT WITH TWO INDEPENDENT VARIABLES	**2 Hours**
	VELOCITY DISTRIBUTION IN TURBULENT FLOW	**2 Hours**
	INTERPHASE TRANSPORT IN ISOTHERMAL SYSTEMS	**4 Hours**
	Friction factors for flow in tubes, flow around spheres, and packed columns.	
	MACROSCOPIC BALANCES FOR ISOTHERMAL FLOW SYSTEMS	**2 Hours**
	Macroscopic mass balance for steady and unsteady-state problems.	
	Tutorial problems based on the topics covered during the theory classes	**15 Hours**
	Total Contact Time: 45 Hours + 15 Hours = 60 Hours	

3.	**Books Recommended**
1	R.B. Bird, W. E. Stewart, E. N. Lightfoot, “Transport Phenomena”, 2nd Edition, John Wiley & Sons, Singapore, 2002.
2	W. J. Thomson, “Introduction to Transport Phenomena”, Pearson Education Asia, Singapore, 2000.
3	R. S. Brodkey, H.C. Hershey, “Transport Phenomena: A Unified Approach”, McGraw-Hill, 1989.
4	J. L. Plawsky, “Transport Phenomena Fundamentals”, Marcel Dekker, New York, 2001.
5	J. C. Slattery, L. Sagis, Oh E-S., “Interfacial Transport Phenomena”, 2nd Edition, Springer, 2007.

M. Tech. I (Chemical Engineering) – Semester - II ADVANCED CHEMICAL REACTION ENGINEERING (CHCH102)	Scheme	L	T	P	Credit
		3	1	0	04

1.	**Course Outcomes (COs):** At the end of the course the students will be able to:
CO1	Analyse the non ideal behaviour of reactors by tracer experiments and suitable models.
CO2	Understand heterogeneous catalysed reactions.
CO3	Design reactors for catalytic reactions.
CO4	Discuss about the applications of supported catalysts.
CO5	Apply the knowledge gained for the environmental impact.
CO6	Distinguish between laboratory and structured reactors.

2.	**Syllabus**	
	NON-IDEAL REACTORS AND RTD STUDIES	**6 Hours**
	Non ideal flow in reactors, RTD of fluid in reactors, E and F curves, Washout and Intensity Functions, Effects of RTD on performance of Chemical Process Equipment, Two-parameter models for analysis of flow through reactors	
	KINETICS OF HETEROGENEOUSLY CATALYSED REACTIONS	**7 Hours**
	Adsorption kinetics, External and internal diffusional and thermal resistances, Diffusion disguised kinetic observations, Effects of heat generation/absorption, Non-isothermal effectiveness factors, LHHW and Eley-Rideal rate expressions, Method of initial rates	
	CATALYSIS	**6 Hours**
	Typical catalysts used in chemical processes, Catalyst characterizations, Design of catalysts, Mechanistic aspects of catalysis	
	CATALYST DEACTIVATION AND REGENERATION PROTOCOL	**3 Hours**
	Modelling catalyst deactivation by coking, sintering, etc., Concept of conversion capacity, Circumventing catalyst deactivation during operation, Catalyst regeneration protocols	
	MULTIPHASE REACTORS	**6 Hours**
	Kinetic analyses of slurry- and trickle bed- reactors, Bubble column slurry reactors, Loop slurry reactors, Hydrodynamics in reactors	
	REACTOR DESIGN	**5 Hours**
	Fixed bed-, Fluid bed-, Trickle bed-, Slurry- reactors	
	ZEOLITE CATALYSIS	**5 Hours**
	Rise of Acidity, Modifications, Shape Selectivity, Inverse shape selectivity, Applications in refining and petrochemicals processes	
	ENVIRONMENTAL CATALYSIS	**2 Hours**
	Importance, Applications	
	LABORATORY REACTORS	**3 Hours**
	Experiments for absence of Intra-particle and extra-particle transport gradients, Criteria for kinetic regime of experiments, Experimental measures of catalyst performance, Guidelines for catalyst testing, Types of laboratory reactors	
	STRUCTURED REACTORS	**2 Hours**
	Configurations, Preparation, Hydrodynamics and Applications, Accelerated Deactivation of catalysts, laboratory reactors, Oscillatory motion of reactants in catalyst pores, Microreactors, Single pellet string reactors.	
	Tutorial problems based on the topics covered during the theory classes	**15 Hours**
	Total Contact Time: 45 Hours + 15 Hours = 60 Hours	

3.	**Books Recommended**
1	H. S. Fogler, "Elements of Chemical Reaction Engineering", 4th Edition, Prentice Hall, NJ, 2006.
2	L. K. Doraiswamy, D. Uner, "Chemical Reaction Engineering Beyond the Fundamentals", CRC Press, New York, 2014.
3	J. M. Smith., "Chemical Engineering Kinetics", 3rd Edition, McGraw-Hill, N Y, 1981.
4	O Levenspiel, "Chemical Reaction Engineering", 3rd Edition, John Wiley & Sons, Singapore, 1998.

5	J. D. Wilde, G. F. Froment., K. B. Bischoff , “Chemical Reactor Analysis and Design”, John Wiley & Sons, Newyork, 1979.

4.	**Additional Reading**
1	P.L. Silverston, “Composition Modulation of Catalytic Reactors”, CRC Press, 1998.
2	Hand-outs from recent publications.
3	“Chemical Reaction Analysis and Design”, John Wiley & Sons, New York 1919.

M. Tech. I (Chemical Engineering) – Semester - II ADVANCED SEPARATION METHODS (CHCH104)	Scheme	L	T	P	Credit
		3	1	0	04

1.	**Course Outcomes (COs):** At the end of the course the students will be able to:
CO1	Describe fundamental concepts of separation processes
CO2	Discuss the principles and process of crystallization
CO3	Identify various membrane-based separation processes and its applications
CO4	Summarize the properties of colloidal separation
CO5	Explain surfactant-based separation
CO6	Discuss supercritical fluid extraction

2.	**Syllabus**	
	MEMBRANE SEPARATION PROCESSES	**26 Hours**
	Reverse Osmosis, Nanofiltration, Ultrafiltration, Microfiltration, Dialysis, Electrodialysis, Gas Permeation, Pervaporation, Liquid Membranes, Membrane Preparation Methods, Membrane Properties and Characterization, Membrane Transport Models, etc.	
	BASICS OF EMERGING MEMBRANE SEPARATION PROCESSES	**7 Hours**
	Membrane Distillation, Membrane Distillation-Crystallization, Membrane Bioreactor, Forward Osmosis, Pressure Retarded Osmosis, Reverse Electrodialysis, Membrane Dryer, etc	
	OTHER SEPARATION METHODS	**12 Hours**
	Supercritical Fluid Extraction, Reactive Separations, Chromatography, Sublimation, Foam Separation, Ion Exchange, Zone Melting, etc.	
	Tutorial problems based on the topics covered during the theory classes	**15 Hours**
	Total Contact Time: 45 Hours + 15 Hours = 60 Hours	

3.	**Books Recommended**
1	P. C. Wankat, “Rate-Controlled Separations”, Elsevier Applied Science/Kluwer, New York, 1994.
2	R. W. Baker, “Membrane Technology and Applications”, 4th Edition, John Wiley and Sons, Chichester (UK), 2023.
3	R. Singh, “Membrane Technology and Engineering for Water Purification”, 2nd Edition, Elsevier Inc., Oxford (UK), 2015.
4	P. M. Bungay, H.K. Lonsdale & M.N. de Pinho (Eds.), “Synthetic Membranes: Science, Engineering and Applications”, NATO ASI Series, Vol.181, D. Reidel Publishing Company, Dordrecht, Holland, 2011.
5	K. Nath, “Membrane Separation Processes”, 2nd Edition, PHI, New Delhi, 2016.

4.	**Additional Reading**
1	Recent literature from Journals on related topics.

M. Tech. I (Chemical Engineering) – Semester - I NANOTECHNOLOGY (CHCH111) Elective	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course the students will be able to:
CO1	To describe about the origin of Nanotechnology and its scope.
CO2	To explain the nanomaterials and their synthesis processes.
CO3	To explain about basics of characterization techniques of nanomaterials.
CO4	To estimate various types of applications and performance.
CO5	To analyse the potential of nanotechnology and new opportunity for future.
CO6	To explain the risk associated with nanoparticles and their remediation.

2.	**Syllabus**	
	INTRODUCTION TO NANOTECHNOLOGY	**5 Hours**
	Global issues, what is nanotechnology, its overview and need, History, nano-scale, its need or significance, scope utilization, applications, importance, properties at nanoscale, applications, Theoretical concepts from Classical Physics and Quantum Mechanics, hazards associated at nanoscale, etc.	
	NANOMATERIALS	**6 Hours**
	Nanoparticles, carbon nanotubes, nanowires, nanofilms, nanostructured bulk materials, magnetic nanoparticles, biological nanoparticles, Applications, etc. Zero-D, One-D, Two-D, Three-Dimensional materials	
	SYNTHESIS OF NANOMATERIALS	**8 Hours**
	Top-down and bottom approach for nano-material synthesis, Sol-Gel process, Microwave heating, Gas phase condensation, Sputtering Techniques, High energy attrition milling, electro depositions, plasma enhanced vapour deposition, physical and chemical vapor deposition, benefits and limitations of each and applications, nanomaterials fabrications by modeling and simulations.	
	CHARACTERIZATION TECHNIQUES	**10 Hours**
	Atomic Force Microscope (AFM), Scanning electron microbiology (SEM), Transmission electron microscopy (TEM), Scanning Tunneling microscopy (STM), Scanning Probe microscopy (SPM), Thermogravimetric analysis (TGA), X-ray diffraction technique (XRD), Particle Size: Nano particle sizer, Plasma emission spectrophotometer. Film thickness: Nano film thickness	
	APPLICATION OF NANOTECHNOLOGY	**10 Hours**
	Environmental Engineering, wastewater treatment, nanocoatings, nanocomposites, nano catalyst, paint industry, glass industry, textile industries, medical, drug delivery, energy sector, nanomembranes, nanosensors, zerovalent iron nanoparticle, nanosized photo catalyst, nano-probs/sensors, FISH, Waste to energy systems, Fuel cell systems, Energy storage devices.	
	RISK OF NANOTECHNOLOGY	**6 Hours**
	Toxic effects, phytotoxicity, limits and guidelines for air, water, soil and future threat, health aspects, Life cycle assessment.	
	Total Contact Time: 45 Hours	

3.	**Books Recommended**
1	T. Pradeep, "A text book of Nanoscience and Nanotechnology", 2017, 2nd Edition.
2	C. Guozhong, "Nanostructure and nanomaterials, synthesis, properties and applications", 2nd Edition, (Imperial College Press), 2019.
3	M. Wilson, "Nanotechnology, basic science and emerging Technology", Chapman & Hall/CRC, 1st Edition, 2002.
4	F.K. Harald, "Nanotechnology, Environmental Aspects", Vol. 2 Wiley 1st Edition, 2008.
5	K.K. Chattopadhyay, A.N. Banarjee, "Introduction to Nanoscience and nanotechnology", 1st Edition, 2009.

M. Tech. I (Chemical Engineering) – Semester - I SMART POLYMERS (CHCH113) Elective	Scheme	L	T	P	Credit
		3	0	0	03

1.	Course Outcomes (COs): At the end of the course the students will be able to:
CO1	Summarize knowledge of basic concepts of polymer and its characterization
CO2	Identify various rheological properties for polymer
CO3	Evaluate polymer properties from different polymerization data
CO4	Understand various properties of smart polymers
CO5	Explain huge potential role of smart polymers in the future technology development
CO6	Describe degradation behavior of polymer and its impact on environment

2.	Syllabus	
	POLYMERIZATION	**4 Hours**
	Mechanism of different polymerization, Newer methods of synthesis of polymers, Special purpose polymers	
	CHARACTERIZATION METHODS	**3 Hours**
	Polymer Characterization i.e., Gel Permeation chromatography (GPC), Concept of different average molecular weight Fourier Transform Infrared Spectroscopy (FTIR), Thermal Analysis, X-ray Diffraction, Electrical Properties, Optical Properties.	
	RHEOLOGICAL PROPERTIES OF POLYMERS	**3 Hours**
	Simple shear flows, elongation flows. Polymer solutions. Relation between properties and structure, crystallinity and orientation. Crosslinking of polymers and elastomers,	
	NEWER METHODS FOR SYNTHESIS OF POLYMERS	**7 hours**
	Classification of nanocomposites & their comparison with normal composites & blends, Different methods of preparation of polymer nanocomposite and blend	
	SPECIAL PURPOSE POLYMER	**8 Hours**
	Polymers responding to various stimuli such as heat, light, pressure, fluids/chemicals etc. Conducting polymers classification/ requirements for conductivity, doping of polymers, light emitting polymers, liquid crystal polymers their classification (LCPs).	
	SMART POLYMERS	**12 Hours**
	Microgels, Protein-based smart polymers, pH-responsive and photo-responsive polymers, Self-assembly, Shape-memory polymers (SMPs), Biodegradable polymers, self-cleaning polymer, Other newer type of polymers.	
	SMART HYDROGELS	**5 Hours**
	Synthesis, Fast responsive hydrogels, Molecular recognition, Smart hydrogels as actuators, Controlled drug release, artificial muscles, Hydrogels in microfluidics	
	BIO- POLYMER AND DEGRADATION	**3 Hours**
	Bio-polymer, Recycling of polymers & environment and Polymer coding, various latest methods of Polymer degradation and its impact on Environment.	
	Total Contact Time: 45 Hours	

3.	Books Recommended
1	N. Yui, R. J. Mrsny, K. Park (Eds.), “Reflexive Polymers and Hydrogels: Understanding and Designing Fast Responsive Polymeric Systems”, CRC Press, 2004.
2	G. B. Mattiasson (Eds.), “Smart Polymers: Applications in Biotechnology and Biomedicine”, 2nd edition, CRC Press, 2008.
3	V. R. Gowariker, N. V. Viswanathan, J. Sreedhar, “Polymer Science”, Halsted Press.
4	B. R. Gupta, “Applied Rheology in Polymer Processing”, Asian Books Private Limited, New Delhi, 2005.
5	M. M. Schwartz, “Composite Material Handbook”, McGraw-Hill company, 1984.

4.	Additional Reading
1	Recent literature from Journals on smart polymer.

M. Tech. I (Chemical Engineering) – Semester - I NANOMATERIALS SYNTHESIS AND APPLICATIONS (CHCH115) Elective	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course the students will be able to:
CO1	Understand the importance of nanomaterials, and types of synthesis methods and their applications
CO2	Learn advantages of chemical synthesis methods of nanomaterials and aspects involved in chemical methods of nanomaterial synthesis
CO3	Learn aspects involved in Colloidal synthesis of various nanostructures and phase behavior
CO4	Learn features involved in Nano catalyst preparation methods and applications
CO5	Learn aspects involved in Nanomaterial synthesis and thin film preparation methods for energy sectors and aspects and controlling operating parameter involved
CO6	Optimization and finding the best optimum parameters using DOE

2.	**Syllabus**	
	OVERVIEW	**2 Hours**
	Importance of nanomaterials, and types of synthesis methods and their applications.	
	FUNDAMENTALS OF CHEMICAL SYNTHESIS AND ENHANCED PROPERTIES	**3 Hours**
	Advantages of chemical synthesis methods of nanomaterials and aspects involved in chemical methods of nanomaterials synthesis, Enhanced Properties at nanoscale.	
	COLLOIDAL SYNTHESIS OF NANOMATERIALS	**3 Hours**
	Colloidal synthesis of various nanostructures. Microemulsion method for nanomaterial synthesis, channels of zeolites, Phase behavior of synthesis systems such as colloidal systems.	
	NANOCATALYSIS: NANOMATERIALS SYNTHESIS FOR NANO CATALYSIS	**10 Hours**
	Nano catalyst preparation methods and applications, Aspects involved in aqueous methods of nanomaterials, coprecipitation, observation and measurement of size and structure at the nanoscale by XRD, AFM, TEM, etc. Nano catalyst preparation methods and applications	
	ENERGY SECTORS: NANOMATERIALS SYNTHESIS	**9 Hours**
	Nanomaterials synthesis and thin film preparation for energy sectors, various types of thin film synthesis methods, Coater and CVD, aspects and controlling operating parameter involved, applications of nanomaterials in Energy sectors such as various types of solar cell.	
	OTHER APPLICATIONS OF NANOMATERIALS: NANOMATERIALS SYNTHESIS	**9 Hours**
	Applications of nanomaterials in various types of fuel cell, water splitting, energy storage etc. Nanowires/nanorods/nanotubes synthesis.	
	OPTIMIZATION OF NANOMATERIALS FORMATION	**8 Hours**
	Optimization of operating parameters, finding the best optimum parameters, use of DOE.	
	SCALE-UP ISSUES IN NANOMATERIALS SYNTHESIS	**1 Hour**
	Issues related to scale-up in nanomaterials synthesis including downstream processing.	
	Total Contact Time: 45 Hours	

3.	**Books Recommended**
1	G. L. Hornyak, H.F. Tibbals, J. Dutta, “Introduction to Nanoscience and Nanotechnology”, CRC Press, Taylor and Francis, US, 2009.
2	N. Singh, “Encyclopedia of Nanoscience and Nanotechnology”, Volume 10, American Scientific Publishers, USA, 2004.
3	C. Brechignac, P. Houdy, M. Lahmani, “Nanomaterials and Nanochemistry, Springer-Verlag Berlin Heidelberg, 2007.
4	G. A. Ozin, A.C. Arsenault, “Nanochemistry: A chemical approach to nanomaterials”, Royal society of chemistry, UK, 2005.
5	J. Ross, “Taguchi Techniques for Quality Engineering”, McGraw-Hill, 1996.

4.	**Additional Reading**
1	M. Ratner, D. Ratner, “Nanotechnology: A gentle introduction to the next big idea”, Prentice-Hall, New Jersey, 2002.
2	K. K. Chatopadhyay, A. N. Banerjee, 2009, PHI Learning Pvt. Ltd., New Delhi, India.

M. Tech. I (Chemical Engineering) – Semester - I INTERFACIAL SCIENCE AND ENGINEERING (CHCH117) Elective	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course the students will be able to:
CO1	Explain about interfaces and methods to measure them
CO2	Summarize various types of colloidal dispersions and their stability
CO3	Describe about the surface forces
CO4	Discuss various transport processes at interface
CO5	Describe the criteria for stability of thin films between interfaces
CO6	Solve the problems of stability of thin films based on given conditions

2.	**Syllabus**	
	INTRODUCTION TO INTERFACIAL SCIENCE AND ENGINEERING	**2 Hours**
	Introduction of colloids and interfacial science, applications and scope of interfacial science and engineering.	
	INTERFACIAL TENSION	**5 Hours**
	Thermodynamic approach of interfacial tension, mechanical approach of interfacial tension, equilibrium shape of fluid interfaces, methods of measuring interfacial tension.	
	INTERFACES	**7 Hours**
	Energy and stress-based characterization, Young-Laplace and Kelvin equations for curved interfaces, flux and momentum balances for interfaces, solid-fluid interfaces, free interfaces, interfaces in motion, rheology of interfaces.	
	COLLOIDAL DISPERSIONS	**8 Hours**
	Forces in colloidal systems, stability of emulsions and foam, DLVO theory, surfactants, self-assembly, thermodynamics of monolayers, micelles, reverse micelles, vesicles, critical miceller concentration, creaming, flocculation, coalescence, Ostwald ripening, zeta potential, electrophoresis, electro-osmosis, micro-emulsions.	
	PARTICLES AT INTERFACES	**7 Hours**
	Pickering emulsions, effects of particles at interfaces, pattern formation, contact angle hysteresis, wetting and spreading, work of adhesion and cohesion.	
	TRANSPORT PHENOMENA AT INTERFACES	**7 Hours**
	Interfacial mass transfer, interfacial instability during mass transfer, transport theorem for body containing intersection dividing surfaces, Marangoni flow, stability of moving interfaces with chemical reactions, dynamic interfaces.	
	BUBBLES, DROPS AND THIN FILMS	**7 Hours**
	Interactions of bubbles or drops in dispersed systems, interaction forces in interfacial systems, stability of thin films	
	SELECTED TOPICS FROM CURRENT LITERATURE	**2 Hours**
	Total Contact Time: 45 Hours	

3.	**Books Recommended**
1	J. C. Slattery, L. Sagis, and Oh E.-S., “Interfacial Transport Phenomena”, 2nd Edition, Springer, New York, 2016.
2	M. J. Rosen, J.T. Kunjappu, “Surfactants and Interfacial Phenomena”, 4th Edition, John Wiley & Sons, New Jersey, 2012.
3	R. J. Stokes, D.F. Evans, “Fundamentals of Interfacial Engineering”, 1st Edition, Wiley – VCH, New York, 1997.
4	C. A. Miller, P. Neogi, “Interfacial Phenomena: Equilibrium and Dynamic Effects”, 2nd Edition, CRC Press, N.Y., 2019.
5	J. N. Israelachvili, “Intermolecular and Surface Forces”, 3rd Edition, Academic Press, New York, 2015.

4.	**Additional Reading**
1	A.W. Adamson, A. Gast, "Physical Chemistry of Surfaces", 6th Edition, John Wiley and Sons, New Jersey, 2011.
2	D. A. Edwards, H. Brenner, D.T. Wasan , "Interfacial Transport Processes and Rheology", Butterworth Heinmen, Oxford, 2013.

M. Tech. I (Chemical Engineering) – Semester - I POLYMER ENGINEERING (CHCH119) Elective	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course the students will be able to:
CO1	Estimate the basic concept of monomer, polymer and polymer blend/composite.
CO2	Classify different polymerization reactions and their mechanisms/kinetics.
CO3	Analyze polymerization data and calculate the conversion and molecular weight.
CO4	Describe the thermal, mechanical and viscoelastic behavior of polymers with respect to their chemical structures and molecular weights.
CO5	Demonstrate an ability to predict polymer degradation.
CO6	Express the knowledge of smart polymer and its uses.

2.	**Syllabus**	
	INTRODUCTION	**2 Hours**
	Monomers, Polymers, Classification of polymers	
	POLYMER CHEMISTRY	**11 Hours**
	Polymerization methods: addition and condensation; their kinetics, Copolymerization, Monomer reactivity ratios and its significance, Kinetics, Different copolymers, random, alternating, azeotropic copolymerization, block and graft copolymers, Techniques for copolymerization-bulk, solution, suspension, emulsion	
	POLYMER CHARACTERIZATION	**10 Hours**
	Concept of average molecular weight, determination of number average, weight average, viscosity average and Z-average molecular weights, Gel Permeation Chromatography (GPC), Membrane osmometry, Dilute solution viscosity method, Ultracentrifugation, Analysis of polymers using IR, XRD, thermal (DSC, DMTA, TGA), microscopic (optical and electronic) techniques.	
	POLYMER BLENDS AND COMPOSITES	**4 Hours**
	Difference between blends and composites, their significance, Choice of polymers for blending, Fiber-reinforced plastic, long and short fibre reinforced composites, Nanocomposites	
	POLYMER TECHNOLOGY	**3 Hours**
	Polymer compounding, Need and significance of polymer compounding, Different compounding Ingredients for polymer, Crosslinking and vulcanization, Smart polymer	
	POLYMER PROCESSING	**7 Hours**
	Compression molding, transfer molding, injection molding, blow molding, reaction injection molding, extrusion, pultrusion, calendaring, rotational molding, thermoforming, rubber processing in two-roll mill, internal mixer. Commodity and general-purpose thermoplastics and thermosetting polymers: PE, PP, PS, PVC, PF, MF, UF, Epoxy, Unsaturated polyester etc.	
	SMART POLYMER	**5 Hours**
	Special purpose polymers, Stimuli response polymers, Self-healing polymer, Conductive polymers, Superabsorbent polymers	
	POLYMER DEGRADATION	**3 Hours**
	Definition, Types of degradation, Nanoplastic, Recent trend polymer degradation.	
	Total Contact Time: 45 Hours	

3.	**Books Recommended**
1	V. R. Gowariker, N.V. Viswanathan, J. Sreedhar, "Polymer Science" 1st Edition, Halsted Press,John Wiley & Sons, New York, 1986.
2	F. W. Billmeyer, "Text Book of Polymer Science, 3rd edition, John Wiley & Sons, New York, 1984.
3	P. Ghosh, "Polymer Science & Technology of Plastic, Rubber, Blends and Composites" 2nd Edition, Tata McGraw-Hill, New delhi, 2008.
4	D. H. Morton-jones, Chapman and Hall, "Polymer Processing", 1st Edition, Springer, London, 1989.
5	N. G. McCrum, C.P. Buckley, C. B. Bucknall, "Principles of Polymer Engineering", 2nd Edition, Oxford Science Publication, 1997.

M. Tech. I (Chemical Engineering) – Semester - I PROCESS INTENSIFICATION (CHCH121) Elective	Scheme	L	T	P	Credit
		3	0	0	03

1.	Course Outcomes (COs): At the end of the course the students will be able to:
CO1	Identify the scope for process intensification in chemical processes & operations.
CO2	Explain the concept of process intensification and the methodologies for PI.
CO3	Explain the operating principle of intensified technologies and its implementation.
CO4	Analyse the range of potential applications of intensified equipment.
CO5	Analyse the range of potential applications of intensified operation/process.
CO6	Appraise process challenges using intensification technologies and solve case studies.

2.	Syllabus	
	INTRODUCTION & PROCESS INTENSIFICATION TECHNIQUES	**6 Hours**
	Historical background & Philosophy, Principles and Domains of Process Intensification (PI), Benefits of Intensified Processes, PI Toolbox – Equipments and Methods, Active and Passive Techniques.	
	COMPACT HEAT EXCHANGERS	**6 Hours**
	Heat transfer intensification, Printed circuit heat exchangers, Foam heat exchangers, Micro-heat exchangers etc.	
	HIGH GRAVITY FIELDS	**6 Hours**
	Process fundamentals, Rotating packed bed, Design, Applications and Scale-up.	
	INTENSIFIED MIXING & REACTORS	**10 Hours**
	PI in stirred tanks, Spinning disc reactors, Structured reactors, Microchannel reactors.	
	REACTIVE SEPARATIONS	**7 Hours**
	Reactive distillation, Reactive absorption, Reactive extraction, Reactive membrane separations	
	ENHANCED FIELDS	**5 Hours**
	Energy based intensifications, Sonochemistry, Microwaves, Electrostatic fields.	
	CASE STUDIES-APPLICATION AREAS	**5 Hours**
	Methodology and Applications, Typical case studies from industrial sectors.	
	Total Contact Time: 45 Hours	

3.	Books Recommended
1	D. Reay, C. Ramshaw, A. Harvey, "Process Intensification: Engineering for Efficiency, Sustainability and Flexibility", 2nd Edition, Butterworth-Heinemann, 2013.
2	K. Boodhoo, A. Harvey, "Process Intensification Technologies for Green Chemistry", John Wiley & Sons, 2013.
3	A. Stankiewicz, J.A. Moulijn, "Re-Engineering the Chemical Processing Plant: Process Intensification", Marcel Dekker, 2004.
4	F. J. Keil, "Modeling of Process Intensification", WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2007.
5	Andrzej Stankiewicz, T. V. Gerven, Stefanidis, "The Fundamentals of Process Intensification", Wiley VCH 2019.

4.	Additional Reading
1	Articles from peer reviewed Journals.

M. Tech. I (Chemical Engineering) – Semester - I MULTIPHASE FLOW (CHCH123) Elective	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course the students will be able to:
CO1	Understand multiphase flow and its principles
CO2	Analysing the theoretical principles for potential applications of multiphase flow
CO3	Integrating interfacial transport phenomena in the multiphase flow systems
CO4	Illustrating the multiphase flow in process industries
CO5	Solving multiphase flow problems
CO6	Assessing the physical understandings of the multiphase flow through interdisciplinary studies

2.	**Syllabus**	
	INTRODUCTION TO MULTIPHASE FLOW	**5 Hours**
	Gas/liquid, liquid/liquid and liquid/solid particle flow systems. Multiphase flows in pipes, flow regime maps, pressure drop.	
	GENERAL CONSERVATION LAWS	**5 Hours**
	Equation of motion for a small spherical particle, Stokes flow around a spherical particle, interfacial flow and constitutive relations.	
	ONE DIMENSIONAL STEADY SEPARATED FLOW	**5 Hours**
	One dimensional steady separated flow model. Phases are considered together but their velocities differ.Phases are considered separately, flow with phase change.	
	SOLID-LIQUID AND GAS-SOLID FLOW	**5 Hours**
	Hydrodynamics of solid-liquid and gas-solid flow. Particle Dynamics: Inertial effects, Two Fluid Models, Turbulence modulation by particles.	
	THREE PHASE FLOW	**4 Hours**
	Introduction to three phase flow	
	MEASUREMENT TECHNIQUES	**6 Hours**
	Measurement techniques for multiphase flow, Flow regime identification, pressure drop, void fraction and flow rate measurement.	
	FLOW IN MICROCHANNELS	**7 Hours**
	Flow in minichannels/microchannels, their principles and applications. Bubble dynamics, Droplet deformation and breakup, Droplet collisions and coalescence.	
	CASE STUDIES-APPLICATION AREAS	**8 Hours**
	Case studies of the multiphase flow. Modeling and simulations using CFD software’s.	
	Total Contact Time: 45 Hours	

3.	**Books Recommended**
1	G. Yadigaroglu, F. Hewitt Geoffrey, “Introduction to Multiphase Flow”, Springer International Publishing, 2018.
2	C. E. Brennen, “Fundamentals of Multiphase Flow”, Cambridge University Press, New York, 2005.
3	C. T. Crowe, “Multiphase Flow Handbook”, Taylor & Francis, Boca Raton, Fl. 2006.
4	V. P. Carey, “Liquid-Vapor Phase-Change Phenomena”, 2nd edition, Taylor & Francis, New York, 2008.
5	E. E. Michaelides , C. T. Crowe, J. D. Schwarzkopf, “Multiphase Flow Handbook”, CRC Press, 2016.

4.	**Additional Reading**
1	D. M. Fries, “Multiphase Flow in Microchannels: Hydrodynamics and Implementation in Process Engineering”, ETH, 2008.

M. Tech. I (Chemical Engineering) – Semester - I ADVANCED MATERIALS AND PROCESSES (CHCH125) Elective	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course the students will be able to:
CO1	Understand the importance of advanced materials, and types of synthesis methods and their applications, learn advantages, chemical synthesis methods of advanced materials and aspects involved in chemical methods of advanced materials synthesis
CO2	Learn features involved in advanced catalyst preparation methods and applications
CO3	Learn aspects involved in advanced materials synthesis and thin film preparation methods for energy sectors and aspects and controlling operating parameter involved
CO4	**Analyse** for best sequence with Heuristics and **Apply** practical knowledge for process simulation. **Design** Multi component Distillation, shortcut method of design
CO5	**Evaluate** Column Diameter and **Apply** Separation process selection thumb rules, and equipment selection thumb rules
CO6	**Design** of heat integration with pinch technology and heat exchanger network design.

2.	**Syllabus**	
	OVERVIEW	**2 Hours**
	Prominence of advanced materials, types of synthesis methods and their applications, Superior Properties of advanced materials.	
	SYNTHESIS AND CHARACTRIZATION OF ADVANCED MATERIALS	**8 Hours**
	Colloidal synthesis of various advanced structures, channels of zeolites, Phase behavior of synthesis systems such as colloidal systems. Characterization and measurement of size and structure of advanced materials by XRD, SEM, UV-VIS,TEM, STM, AFM etc	
	APPLICATIONS OF ADVANCED MATERIALS IN CATALYSIS	**3 Hours**
	Advanced catalyst preparation methods and applications, Aspects involved in aqueous methods of advanced materials, co-precipitation	
	APPLICATIONS OF ADVANCED MATERIALS IN EMERGING ENERGY SECTORS	**9 Hours**
	Advanced materials synthesis and thin film preparation for energy sectors, various types of thin film synthesis methods, Coater and CVD, aspects and controlling operating parameter involved, applications of advanced materials in Energy sectors such as various types of solar cell., applications of advanced materials in various types of fuel cell, water splitting, energy storage etc.	
	ADVANCES PROCESS AND PROCESS EQUIPMENT	**10 Hours**
	Advances process, Multicomponent distillation column design, Methods including Heuristics for best sequence selection, Column Design for Distillation and Absorption, optimum design, parameter optimization etc. Computer aided design of chemical process equipment’s	
	SEPARATION METHOD SELECTION AND EQUIPMENT SELECTION	**4 Hours**
	Separation process selection criteria’s and general thumb rules, equipment selection criteria’s and general thumb rules	
	HEAT INTEGRATION AND HEAT EXCHANGER NETWORK DESIGN	**9 Hours**
	Heat integration, Pinch technology, and Optimum number of heat exchanger and its design	
	Total Contact Time: 45 Hours	

3.	**Books Recommended**
1	Z. D. Jastrzebski, “Nature and Properties of Engineering Materials”, 2nd Edition, John Wiley & Sons, 1976.
2	J. Douglas, “Conceptual Design of Chemical Processes”, McGraw-Hill, New York, 1989.
3	W. F. Smith, J. Hashemi, R. Prakash, “Materials Science and Engineering”, 4th Edition, McGraw - Hill, 2010.
4	R. Smith, “Chemical Process Design”, 2nd Edition, McGraw-Hill, New York, 2016.
5	W.D.Sieder, J. D. Seader, D. R. Lewin, “Product and Process Design Principles”, 4th Edition, John-Wiley, New York, 2016.

M. Tech. I (Chemical Engineering) – Semester - II COMPLEX FLUIDS (CHCH112) Elective	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course the students will be able to:
CO1	Classify types of different types of complex fluids.
CO2	Evaluate the rheological characteristics of the complex fluids.
CO3	Identify the rheological property responsible for the deformation characteristics.
CO4	Select appropriate test for evaluating rheological properties of complex fluids.
CO5	Apply the knowledge of rheology to test the rheology of complex fluids.
CO6	Apply the concepts to design new complex fluids with improved rheology.

2.	**Syllabus**	
	INTRODUCTION COMPLEX FLUIDS	**3 Hours**
	Types of fluids, features and applications of complex fluids, non-Newtonian behavior, stresses, deformation and flow, Importance of study of rheology, rheological properties, mechanical rheological techniques, use of rheological data for development of new products	
	DEFORMATION OF COMPLEX FLUIDS	**8 Hours**
	Deformation characteristics, Rheology, Viscoelasticity, Linear viscoelasticity. Non-linear viscoelasticity: Rate - dependent and time-dependent shear and extensional viscosity, time-dependent superposition, normal stresses in shear. Elementary theories of non-linear viscoelastic behavior	
	RHEOLOGICAL STUDIES OF COMPLEX FLUIDS	**7 Hours**
	Shear rheology, extensional rheology, compressional rheology and their applications	
	COMPUTATIONAL RHEOLOGY	**6 Hours**
	Micro-macro approach, methods of computational rheology,	
	POLYMERIC COMPLEX FLUIDS	**6 Hours**
	Structure of polymeric complex fluids, molecular origin of polymer melts, concentrated solution, rheological behavior of polymer melts, non-linear viscoelasticity of entangled polymers, flexible polymers, linear viscoelasticity of entangled polymers, polymer gels, transient network models, fine-grained theories of polymer dynamics, kinetic theory models for dilute polymer solutions	
	RHEOLOGY OF DISPERSIONS	**6 Hours**
	Flow properties of suspensions, emulsions, filled systems, gels, yield stresses of particulate gels, their measurements and applications	
	RHEOMETRY	**3 Hours**
	Testing methods, shear and extensional rheometry, Measurement of rheology in shearing deformation and flows, techniques of measurement, features of various types of rheometers.	
	SELECTED TOPICS FROM CURRENT LITERATURE	**6 Hours**
		Total Contact Time: 45 Hours

3.	**Books Recommended**
1	R. P. Chhabra, J. F. Richardson, "Non-Newtonian Flow and Applied Rheology: Engineering Applications", 2^{nd} Edition, Butterworth Heinemann, Oxford, 2008.
2	R. Pal, "Rheology of Particulate Dispersions and Composites", CRC Press, New York, 2007.
3	R. G. Larson, "The Structure and Rheology of Complex Fluids", Oxford University Press, New York, 1999.
4	R.G. Owens, T. N. Phillips, "Computational Rheology", Imperial College Press, London, 2002.
5	A. Y. Malkin, A. I. Isayev, "Rheology: Concepts, Methods and Applications", ChemTec Publishing, Canada, 2005.

M. Tech. I (Chemical Engineering) – Semester - II **INDUSTRIAL BIOTECHNOLOGY (CHCH114)** **Elective**	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course the students will be able to:
CO1	Comprehend the principles behind Industrial biotechnology
CO2	Solve problems related to kinetics of enzymes and interpret actions
CO3	Design the concepts related to Bioreactor design
CO4	Describe broad understanding of concepts and applications of microorganism
CO5	Develop mathematical models in biotechnology
CO6	Impart the knowledge to apply in sustainable biotechnology, environmental biotechnology and nano - biotechnology

2.	**Syllabus**	
	INTRODUCTION	**3 Hours**
	Key factor for development of Biotechnology processes. Classification and Nomenclature of Microorganism, Staining Method, Method of Determination of cell no and mass, genetically engineering Cell	
	ENZYMES	**8 Hours**
	Enzyme kinetics introduction, Mechanistic models for simple enzyme kinetics, models for more complex enzyme kinetics, Models for pH and temperature effect on enzymes and deactivation kinetics. Immobilized enzyme systems, applied enzyme catalysis.	
	BIOREACTORS	**6 Hours**
	Different types of bioreactors and bioreactor design, application of artificial intelligence in bioprocess control.	
	MICROBIAL GROWTH	**8 Hours**
	Microbial growth, substrate degradation and product formation kinetics, stoichiometric microbial growth and product formation	
	SUSTAINABLE BIOTECHNOLOGY	**6 Hours**
	Plants as source of chemicals, Microbial production of chemicals, Microbial polymers, Microbial plastics, Industrial processes and clean technology	
	NANOBIOTECHNOLOGY	**4 Hours**
	Biosensor, Biomaterials, nano-medicine.	
	MATHEMATICAL METHODS IN BIOTECHNOLOGY	**6 Hours**
	Classification of mathematical models applicable in biotechnology with applications examples. Statistical analysis, Testing mathematical models.	
	ENVIRONMENTAL BIOTECHNOLOGY	**4 Hours**
	Bioremediation, Biofuels, Biofouling, Natural resource recovery.	
	Total Contact Time: 45 Hours	

3.	**Books Recommended**
1	L. M. Shuler, F. Kargi, “Bioprocess Engineering: Basic Concepts: International edition”, 3rd Edition, Prentice Hall International Series, 2017.
2	J. E. Bailey, D. F. Ollis, “Biochemical Engineering Fundamentals”, 2nd Edition, McGraw-Hill, 1986.
3	D. Das, S. Pandit, “Industrial Biotechnology”, 1st Edition, CRC Press, Boca Raton, FL, USA, 2021.
4	B. K. Dutta, “Mathematical Methods in Chemical and Biological Engineering”, 1st Edition., CRC Press, Boca Raton, FL, USA, 2017.
5	A. Scragg, “Environmental Biotechnology”, 2nd Edition., Oxford University Press, 2005.

M. Tech. I (Chemical Engineering) – Semester - II ENVIRONMENT, HEALTH AND SAFETY (CHCH116) Elective	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course the students will be able to:
CO1	To describe the environmental ecosystem and its significance.
CO2	To analyze the effects of pollutants on the environment and health.
CO3	To estimate and decide the treatment technologies for waste effluents.
CO4	To justify the significance of safety for industries and available laws.
CO5	To estimate the hygiene and occupational health in industrial environment.
CO6	To design and illustrate the treatment methodologies for resource generation.

2.	**Syllabus**	
	INTRODUCTION	**5 Hours**
	Importance of Environment, its components, ecology, biosphere, interaction, impact of development, pollution and its effects, reversibility of environment. Safety, Health and safe practices in industries and its importance, sources of pollution from Chemical Industries, public awareness, and sustainability	
	IMPACT ON BIOLOGICAL ENVIRONMENT	**10 Hours**
	Discharge of various effluents (water, air, and solid) and their impacts on environmental and human health, characterization, identification, different treatment processes (chemical, biological, and advanced), mix first and separate later (MFSL) approach and its disadvantages, decentralization, tertiary treatment, and disinfection.	
	SOLID WASTE TREATMENT AND DISPOSAL	**8 Hours**
	Definition, Types of solid waste, generation, onsite handling, storage & processing, Different types of disposal techniques, recovery of resources, reuse of solid waste, electronic waste, policies, and current practices.	
	SAFETY PRACTICES IN INDUSTRIES	**5 Hours**
	Safety, loss prevention, safe practice, codes of safety, and integrity for various types of processes, safety and morals, accidents, accident reporting and investigation, personal protective equipments', releases mitigation procedures, financial aspects of safety, case histories, release of toxic effluents	
	INDUSTRIAL HYGIENE AND OCCUPATIONAL HEALTH	**6 Hours**
	Industrial hygiene, health and environmental effects, safety and health training, stress safety, radiations and industrial hazards, industrial noise, vibration, electric hazards, Disposal of scrap and other trade wastes, spillage prevention, housekeeping and its advantages, First aid, causalities and injuries.	
	LEGISLATIVE MEASURES	**5 Hours**
	Different laws related to liquid, solid, and gases effluents, Different standards and legislations, Factories Act, Workman's Compensation Act, Air Water Pollution Act, Bureau of Indian Standards on safety and health, OSHA, etc.	
	RESOURCE GENERATION	**6 Hours**
	Minimizing waste generation, reduce, reuse and recycling of by-products, Waste utilization, waste to energy concept, Sustainability, various advanced techniques like UASB, MFC, OMFC etc	
	Total Contact Time: 45 Hours	

3.	**Books Recommended**
1	G. M. Masters, "Introduction to Environmental Engineering and Science", 3rd Edition, Prentice-Hall, New Delhi, 2008.
2	S. MaCarty, "Chemistry for Environmental Engineering", 5th Edition, Tata-McGraw-Hill, New Delhi.
3	Metcalf & Eddy, "Waste Water Engineering: Treatment, Disposal and Reuse", 4th Edition, Tata-McGraw-Hill, New Delhi, 2002.
4	D.A. Crowl, J. F. Louvar , "Chemical Process Safety", 2nd Edition, Prantice-Hall, New York, 2002.
5	A. K. Mungray, A. A. Mungray, S. S. Sonawane, S. H. Sonawane, "Novel Approaches Towards Wastewater Treatment and Resource Recovery Technologies", 1st Edition, Elsevier Publication 2022.

4.	**Additional Reading**
1	F. P. Lees, “Loss Prevention in Process Industries”, Butterworths, NewDelhi, 4th Edition., 2012.
2	C. S. Rao, “Environmental Engineering”, Wiley Eastern Limited, New Delhi, 1995.
3	R. L. Droste, “Theory and Practice of Water and Wastewater Treatment”, Wiley India, 1996.
4	C. P. L. Grady, G. Daigger, H. C. Lim, “Biological Waste Water Treatment”, 2nd Edition, Marcel Dekker, 1999.
5	Research Papers.

M. Tech. I (Chemical Engineering) – Semester - II COMPUTATIONAL FLUID DYNAMICS (CHCH118) Elective	Scheme	L	T	P	Credit
		3	0	0	03

1.	Course Outcomes (COs): At the end of the course the students will be able to:
CO1	Understanding the fundamentals of computational methods in fluid flow operations
CO2	Analysing the initial and boundary value problems
CO3	Integrating the appropriate solution methodology and estimating the accuracy of the results for a given flow case
CO4	Solving CFD problems using appropriate boundary conditions
CO5	Adapting to various CFD software for solving interdisciplinary problems
CO6	Illustrating the computational results for the given case

2.	Syllabus	
	INTRODUCTION AND GOVERNING EQUATIONS	**5 Hours**
	Introduction, Classification of partial differential equations, Navier-Stokes system of equations, Boundary conditions.	
	FINITE DIFFERENCE METHODS	**5 Hours**
	Basic aspects of finite difference equations, Derivation of finite difference equations, Accuracy of finite difference solutions	
	SOLUTION METHODS OF FINITE DIFFERENCE EQUATIONS	**7 Hours**
	Methods for Elliptic, Parabolic and Hyperbolic equations, Implicit and explicit schemes, Von Neumann stability analysis, Example problems	
	INCOMPRESSIBLE VISCOUS FLOWS	**7 Hours**
	General, Artificial compressibility method, Pressure correction methods, Vortex methods.	
	COMPRESSIBLE FLOWS	**6 Hours**
	Potential equation, Euler equations, Navier-Stokes system of equations, Preconditioning process for compressible and incompressible flows.	
	INTRODUCTION TO FINITE VOLUME METHOD	**5 Hours**
	Integral approach, discretisation & higher order schemes.	
	INTRODUCTION TO FINITE ELEMENT METHOD	**4 Hours**
	Finite element formulations, definition of errors, Finite element interpolation functions.	
	APPLICATIONS	**6 Hours**
	Chemically reactive flows, Heat transfer and Multiphase flow.	
	Total Contact Time: 45 Hours	

3.	Books Recommended
1	J. D. Anderson, "Computational Fluid Dynamics", McGraw-Hill International Editions, 1st Edition, 1995.
2	S. V. Patankar, "Numerical Heat Transfer and Flow", Taylor & Francis, Reprinted 1st Edition, 2004.
3	J. H. Ferziger, M. Peric, "Computational Methods in Fluid Dynamics", Springer, 1st Edition, 2003.
4	K. Muralidhar, T. Sunderrarajan, "Computational Fluid Flow and Heat Transfer", Alpha Science International, 2nd Edition, 2003.
5	T. J. Chung, "Computational Fluid Dynamics", Cambridge University Press, 2nd Edition, 2014.

M. Tech. I (Chemical Engineering) – Semester - II DESIGN OF EXPERIMENTS (CHCH120) Elective	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course the students will be able to:
CO1	Explain the importance of statistical approach in research and experimental planning.
CO2	Select suitable data set for analysis of the results.
CO3	Devise effective ways to conduct experiments and obtain optimum conditions.
CO4	Perform analysis of variance for analysing effect of various factors studied.
CO5	Apply various methods of factorial designs (2^K method, Response surface method, Taguchi method) for a given set of parameters.
CO6	Able to use software for analysis of the experimental results.

2.	**Syllabus**	
	REVIEW OF BASIC STATISTICAL CONCEPTS	**8 Hours**
	Measures of central tendency, sampling distribution, hypothesis testing, p-value, Type-I and Type-II error, confidence interval, central limit theorem	
	FUNDAMENTALS OF EXPERIMENTAL DESIGN	**10 Hours**
	Experimentation, basic principles of design, steps in experimentation, linear regression, multiple and partial correlation coefficients	
	INTRODUCTION TO THE ANALYSIS OF VARIANCE (ANOVA)	**8 Hours**
	Understanding variation, No-way ANOVA, One-way ANOVA, Two-way ANOVA, Three-way ANOVA	
	2^K FACTORIAL EXPERIMENTS AND DESIGNS	**6 Hours**
	2^2 Factorial design, 2^3 Factorial design, 2^k Factorial design, Blocking and confounding	
	SINGLE, MULTI-FACTORIAL EXPERIMENTS	**5 Hours**
	Completely randomized design, Block Design, Latin and Graeco-latin square design, Degree of freedom and sum of squares, Use of Excel and relevant software	
	RESPONSE SURFACE METHODS	**4 Hours**
	Response surface designs (Central composite design; Box-behnken design), Use of Excel and relevant software	
	TAGUCHI METHOD	**4 Hours**
	Nominal-the better case, Smaller-the better case, Larger-the better case, Estimation of quality loss, Introduction to orthogonal designs, Robust design; Data analysis, Multi-response optimization, Use of Excel and relevant software	
	Total Contact Time: 45 Hours	

3.	**Books Recommended**
1	P. J. Ross, “Taguchi Techniques for Quality Engineering”, McGraw-Hill Book Co, New York, U.S.A., 1989.
2	K. Krishnaiah, P. Shahabudeen, “Applied Design of Experiments and Taguchi Methods”, PHI Learning, India, 2012.
3	G. Taguchi, S. Chowdhury, Y. Wu, “Taguchi’s Quality Engineering Handbook”, John Wiley and Sons, New York, U.S.A., 2005.
4	D. C. Montgomery, “Design and Analysis of Experiments”, 5^{th} Edition, John Wiley and Sons, New York, U.S.A., 2001.
5	Z. R. Lazic, “Design of Experiments in Chemical Engineering”, Wiley-VCH Verlag GmbH & Co., Germany, 2004.

M. Tech. I (Chemical Engineering) – Semester - II **ADVANCED PROCESS CONTROL (CHCH122)** **Elective**	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course the students will be able to:
CO1	Explain the concept of advanced control schemes used in process control
CO2	Develop control relevant linear perturbation models
CO3	Explain the concept of digital control system
CO4	Elaborate the use of soft computing techniques in process control
CO5	Analyze interaction in multi loop control
CO6	Analyze stability of digital control system

2.	**Syllabus**	
	INTRODUCTION AND MOTIVATION	**4 Hours**
	Introduction, Application; Plant wide control	
	DIGITAL SAMPLING, FILTERING AND CONTROL	**6 Hours**
	Sampling and signal reconstruction, Signal processing and data filtering	
	DEVELOPMENT OF CONTROL RELEVANT LINEAR PERTURBATION MODELS	**7 Hours**
	Development of Control Relevant Linear Perturbation Models; Linearization of Mechanistic Models; Introduction to z-transforms and Development of Grey-box models	
	DEVELOPMENT OF LINEAR BLACK-BOX DYNAMIC MODELS	**10 Hours**
	Introduction to Stochastic Processes; Development of ARX models; Statistical Properties of ARX models and Development of ARMAX models; Issues in Model Development; Model Structure Selection and Issues in Model Development; Issues in Model Development and State Realizations of Transfer Function Models	
	STABILITY ANALYSIS, INTERACTION ANALYSIS AND MULTI-LOOP CONTROL	**6 Hours**
	Stability Analysis of Discrete Time Systems; Lyapunov Functions; Jury's Stability Test.	
	MULTILOOP AND MULTIVARIABLE CONTROL	**6 Hours**
	Interaction Analysis and Multi-loop Control; Pairing of controlled and Manipulated Variables; RGA and Singular Value Analysis; Decoupling and Multivariable Control Stratigies	
	STATE ESTIMATION AND KALMAN FILTERING	**6 Hours**
	Soft Sensing and State Estimation, Development of Luenberger Observer; Introduction to Kalman Filtering	
	Total Contact Time: 45 Hours	

3.	**Books Recommended**
1	K. J. Astrom, B. Wittenmark, "Computer Controlled Systems", Prentice Hall India, 3rd Edition, 1997.
2	G. F. Franklin, J. D. Powell, M. L. Workman, "Digital Control Systems", Addison Wesley, 3rd Edition, 1997.
3	D. E. Seborg, T. F. Edgar,D. A. Mellichamp, "Process Dynamics and Control", Wiley, 3rd Edition, 2010.
4	G. C. Goodwin, S.F. Graebe, M. E. Salgado, "Control System Design", Prentice Hall, 1st Edition, 2000.
5	G. Stephanopoulos, "Chemical Process Control: An Introduction to Theory and Practice",1st Edition, Prentice Hall India, 2008.

M. Tech. I (Chemical Engineering) – Semester - II CATALYST SCIENCE AND TECHNOLOGY (CHCH124) Elective	Scheme	L	T	P	Credit
		3	0	0	03

1.	Course Outcomes (COs): At the end of the course the students will be able to:
CO1	Describe concepts and significance related to heterogeneous and homogeneous catalysts
CO2	Explain steps and methods in catalyst preparation
CO3	Describe and apply selected catalyst characterization methods (identify analytical tools for specific catalytic applications)
CO4	Explain why and how catalysts deactivate and how catalyst deactivation can be postponed or prevented
CO5	Outline dis-/advantages of supported and full-catalysts with respect to their application
CO6	Explain industrial catalytic processes

2.	Syllabus	
	INTRODUCTION TO CATALYSIS	**2 Hours**
	Significance of catalysis, Heterogeneous Catalysis: Examples, Case Histories and Current Trends.	
	SOLID CATALYSIS	**6 Hours**
	Types of catalysts, Preparation methods of Solid Heterogeneous Catalysts, Catalyst supports, Activation.	
	CATALYSTS CHARACTERIZATION METHODS	**8 Hours**
	Adsorption methods, Physicochemical Properties, Spectroscopic Methods.	
	CATALYST PERFORMANCE	**4 Hours**
	Testing of catalysts, activity and selectivity studies.	
	EFFECT OF TRANSPORT PROCESSES	**4 Hours**
	External transport processes, internal transport processes for reaction and diffusion in porous catalysts	
	MECHANISM OF CATALYTIC REACTIONS	**4 Hours**
	Rates of adsorption, desorption, surface reactions, rate determining steps.	
	KINETIC MODELLING AND PARAMETER ESTIMATIONS	**4 Hours**
	Kinetic study and parametric evaluation.	
	CATALYSTS DEACTIVATION	**2 Hours**
	Promoters, inhibitors, catalyst deactivations, kinetics of catalyst deactivations.	
	INDUSTRIAL CATALYSIS APPLICATION	**6 Hours**
	Green Chemistry, Biomass to biofuels and chemicals, CO_2 utilization etc.	
	NEW DEVELOPMENT IN SOLID CATALYSIS	**2 Hours**
	Monolith catalysts, Nanocatalysts, etc.	
	INTRODUCTION TO HOMOGENEOUS CATALYSIS	**3 Hours**
	Total Contact Time: 45 Hours	

3.	Books Recommended
1	J. M. Thomas, W. J. Thomas, "Principles and Practice of Heterogeneous Catalysis", Wiley- VCH., 2015.
2	C. H. Bartholomew, R. J. Farrauto "Fundamentals of Industrial catalytic Processes", Wiley- VCH., 2010.
3	Julian Ross, “Heterogeneous Catalysis - Fundamentals and Applications”, Elsevier, 2012.
4	S. Lowell, Joan E. Shields, Martin A. Thomas, Matthias Thommes, “Characterization of Porous Solids and Powders: Surface Area, Pore Size and Density”, Springer Science, New York, 2004.
5	Fogler H.S., “Elements of Chemical Reaction Engineering”, 4^{th} Edition, Prentice Hall, NJ, 2006.

4.	Additional Reading
1	Articles from Peer Reviewed Journals.

M. Tech. I (Chemical Engineering) – Semester - II SUSTAINABLE DEVELOPMENT GOALS (CHCH126) Elective	Scheme	L	T	P	Credit
		3	0	0	03

1.	Course Outcomes (COs): At the end of the course the students will be able to:
CO1	Understand critically emergence and development of the Sustainable Development Goals (SDGs)
CO2	Identify and apply different methods for assessing clean water
CO3	Evaluate sustainabable solutions for SDGs using different approach and calculation
CO4	Describe various potentials ways to get affordable and clean energy
CO5	Explain current challenges i.e., social, environmental and econmic in achieving the SDGs
CO6	Examine how the different SDGs are implemented and interrelated

2.	Syllabus	
	THE ORIGIN, DEVELOPMENT AND IDEA OF THE SDGs	**11 Hours**
	History and origins of the Sustainable Development Goals. What are the SDGs? What are their aims, methodology and perspectives? How are they related to the Millennium Development Goals?	
	CLEAN WATER	**13 Hours**
	Overview of conventional wastewater treatment plant, Biological treatment: Principles of biological treatment, kinetics of biological growth, aerobic (ASP) and anaerobic treatment (UASB) of sewage. Activated sludge, Trickling filters, biological disc, packed bed and fluidized bed treatment, stabilization ponds, Advanced waste water treatment: Principles of tertiary treatment (membrane based treatment i.e., MF, UF, NF and RO), reuse and resource recovery, and recent developments i.e., forward osmosis (FO), membrane bio reactor (MBR), Pressure retarded osmosis (PRO) and Pressure assisted FO (PAFO), Seawater Desalination	
	SANITATION	**10 Hours**
	Concept of environment and scope of sanitation in rural areas. Magnitude of problem of water supply and sanitation. National policy. On site sanitation system i.e., septic tanks, soakage pits etc., Composting, land filling, Biogas plants.	
	AFFORDABLE CLEAN ENERGY	**11 Hours**
	Examples of future Clean Technology, Biodiesel, Natural Compost, Eco-Friendly Plastic, Alternate Energy, Hydrogen, Bio-fuels. Solar Energy, Wind, Hydroelectric Power, Biotransformation of biomass/organic waste into value added chemicals energy, Bio-fertilizers, Microbial fuel cell (MFC), Osmotic microbial fuel cell (OMFC), Benthic microbial fuel cell (BMFC), Hybrid OMFC etc.	
	Total Contact Time: 45 Hours	

3.	Books Recommended
1	R.W. Baker, “Membrane Technology and Application”, John Wiley and Sons Ltd., 2004.
2	Dalby, Simon, “Achieving the Sustainable Development Goals: Global Governance Challenges”, Routledge, 2019.
3	C.S. Rao, “Environmental Engineering”, Wiley Eastern Limited, New Delhi, 1995.
4	APHA, “Standard Methods for Examination of Water and Wastewater”; 21st Edition, 2002.
5	Metcalf and Eddy, “Wastewater Engineering, Treatment”, Disposal and Reuse, Inc. 3rd Edition McGraw-Hill 1991.

M. Tech. I (Chemical Engineering) – Semester - II CORROSION AND ELECTROCHEMICAL ENGINEERING (CHCH172) Institute Elective	Scheme	L	T	P	Credit
		3	0	0	03

1.	Course Outcomes (COs): At the end of the course the students will be able to:
CO1	Apply laws of electrochemistry to understand mechanism of corrosion
CO2	Estimate the rate of corrosion.
CO3	Differentiate between different types of corrosion.
CO4	Identify the factors causing corrosion and solve problems involving various types of corrosion.
CO5	Assessment of damage caused by corrosion.
CO6	Select suitable technique for corrosion prevention.

2.	Syllabus	
	ELECTROCHEMISTRY OF CORROSION	**6 Hours**
	Corrosion – introduction and definitions; Electrochemical cells - definitions and principles; Potential measurements - galvanic cells, concentration cells; EMF and Galvanic series - bimetallic couples; Eh-pH diagrams – fundamental aspects; Construction of Eh – pH diagrams; FeH2O-O2 diagram; Copper, aluminium and general corrosion diagrams	
	CORROSION KINETICS AND APPLICATION OF ELECTROCHEMISTRY	**11 Hours**
	Over potential; Activation Polarization; Concentration Polarization; Ohmic Drop; Graphical Presentation of Kinetic Data (Evans Diagrams); Activation Controlled Processes; Concentration Controlled Processes; Examples of Applied Electrochemistry to Corrosion; Electrochemical Polarization Corrosion Testing; Corrosion Monitoring; Cathodic Protection; Anodic Protection; Aluminum Anodizing; Chloride Extraction.	
	FORMS OF CORROSION	**7 Hours**
	Recognizing Corrosion; Localized Corrosion (Pitting Corrosion, Crevice Corrosion, Galvanic Corrosion, Intergranular Corrosion, Dealloying, Hydrogen-Induced Cracking, Hydrogen Blistering, etc.); Velocity Induced Corrosion (Erosion–Corrosion, Cavitation, etc.); Mechanically Assisted Corrosion (Stress Corrosion Cracking, Corrosion Fatigue, Fretting Corrosion, etc.).	
	FACTORS AFFECTING CORROSION AND ITS MONITORING	**9 Hours**
	Effect of ambient conditions; Corrosion by fresh water and other types of water; Corrosion by atmosphere; corrosion in soil; Microbiologically affected corrosion; Corrosion in concrete; corrosion in petroleum industries; Corrosion Test Methods and Testing Procedure; Electrochemical Testing; Corrosion Monitoring and Inspection; Monitoring of Cathodic Protection; Inspection and Monitoring of Process Plants; Monitoring and Testing in Other Environments	
	RISK ASSESSMENT OF CORROSION AND ITS MITIGATION	**12 Hours**
	Risk assessment and analysis; Risk assessment methods; Cost of corrosion; Hazard and operability; Failure modes – effects and criticality analysis; Risk matrix methods; Fault tree analysis; Event tree analysis; Industrial example of corrosion assessment and damage assessment; Cathodic protection; Sacrificial cathodic protection; Impressed current cathodic protection; Protective coatings - types of coatings; coatings failure; Economic aspects of coating selection and maintenance; Organic coatings; Inorganic (non-metallic) coatings; Metallic coatings; Coating inspection and testing; Surface preparation.	
	Total Contact Time: 45 Hours	

3.	Books Recommended
1	P. R. Roberge, “Corrosion engineering: principles and practice”, 1st Edition, New York: McGraw-Hill, 2008.
2	R. G. Kelly, J. R. Scully, D. Shoesmith, R. G. Buchheit, “Electrochemical techniques in corrosion science and engineering”, 1st Edition, CRC Press, 2002.
3	E. Bardal, “Corrosion and protection”, 1st Edition, Springer Science & Business Media, 2004.
4	D. Landolt, “Corrosion and surface chemistry of metals”, 1st Edition, EPFL press, 2007.
5	Z. Ahmad, “Principles of corrosion engineering and corrosion control”, 1st Edition, Elsevier Science and Technology Books, 2006.

M. Tech. I (Chemical Engineering) – Semester - II NON-CONVENTIONAL ENERGY (CHCH174) Institute Elective	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course the students will be able to:
CO1	Identify energy demand and relate with available energy resources
CO2	Understand the basics of various nonconventional energy systems
CO3	Demonstrate the generation of electricity/energy from various Non-Conventional sources, have a working knowledge on types of fuel cells
CO4	Analyze harnessing of various nonconventional techniques like solar, biomass, wind, hydrogen, Ocean, fuel cells, etc.
CO5	Evaluate the hydrogen and other various fuel cell for the conversion of chemical energy to electrical energy
CO6	Design and illustrate the nonconventional energy conversion systems for real applications

2.	**Syllabus**	
	INTRODUCTION	**2 Hours**
	Overview of World Energy and India's Energy Scenario, Scale of quantities, Impact of current energy usage, Conventional sources of energy, Overview of non-conventional energy resources, environmental aspects of energy utilization, conventional and non-conventional sources of energy, merits and challenges, Introduction to various renewable energy sources.	
	SOLAR ENERGY	**8 Hours**
	Solar energy incident on earth, solar spectrum, overview of solar energy technologies, performance and durability of solar devices. Solar thermal energy conversion: Solar radiation on the earth surface, measurement of solar radiations, concentrating and non-concentrating types of solar collectors, various solar thermal applications, examples of systems. Solar electrical energy conversion: Construction and working of solar cells, materials and PV modules, different PV technologies, photovoltaic system components and different applications, power plants, case studies.	
	WIND ENERGY	**6 Hours**
	Principle of wind energy conversion; Basic components of wind energy conversion systems; wind mill components, various types and their constructional features; design considerations of horizontal and vertical axis wind machines: analysis of aerodynamic forces acting on wind mill blades and estimation of power output; wind data and site selection considerations.	
	BIOMASS ENERGY	**11 Hours**
	Biomass conversion technologies, Biogas generation plants, Classification, advantages and disadvantages, constructional details, site selection, digester design consideration, filling a digester for starting, maintaining biogas production, Fuel properties of bio gas, utilization of biogas. Waste as liquid fuels and utilization of Bio-electrochemical systems for conversion of chemical to electrical energy, principles, application and potentials.	
	OCEAN ENERGY	**5 Hours**
	Ocean thermal electric conversion, open and closed cycle of OTEC, basic principles of tidal power & components of tidal power plants, single & double basin arrangements, Energy from ocean waves, wave energy conversion devices. Tidal Energy-Principle of working, performance and limitations. Wave Energy-Principle of working, performance and limitations. Ocean Thermal Energy- Availability, theory and working principle, performance and limitations.	
	GEOTHERMAL ENERGY	**3 Hours**
	Estimation and nature of geothermal energy, geothermal sources and resources like hydrothermal, geo-pressured hot dry rock, magma. Advantages, disadvantages and application of geothermal energy, prospects of geothermal energy in India.	
	HYDROGEN ENERGY	**4 Hours**
	Hydrogen Production methods, Hydrogen storage, hydrogen transportation, utilization of hydrogen gas, hydrogen as alternative fuel for vehicles, limitations and future. Principle of working of various types of fuel cells and their working, performance and limitations.	
	BIOGAS ENERGY	**6 Hours**
	Principle of bio gas generation, constructional details of various biogas plants, factors affecting generation of biogas and methods of maintaining biogas, Bio Mass: Introduction, methods of obtaining energy from	

	biomass, thermal gasification**.**
	Total Contact Time: 45 Hours

3.	**Books Recommended**
1	G. D. Rai, “Non-Conventional Energy Sources”, 4th Edition, Khanna Publishers, 2000.
2	S. P. Sukhatme, “Solar Energy”, 3rd Edition, Tata McGraw-Hill Education Pvt Ltd, 2008.
3	B. H. Khan, “Non-Conventional Energy Resources”, 2nd Edition, Tata McGraw-Hill Education Pvt Ltd, 2011.
4	S. Hasan, D. K. Sharma, “Non-Conventional Energy Resources”, 3rd Edition, S. K. Kataria & Sons, 2012.
5	G. N. Tiwari, M. K. Ghosal, “Renewable Energy Resource: Basic Principles and Applications”, Narosa Publishing House, 2004.

4.	**Additional Reading**
1	J. Twidell, T. Weir, “Renewable Energy Resources”, Taylor & Francis; 2nd Edition, 2005.
2	B. E. Logan, “Microbial Fuel Cells”, 1st Edition, Wiley (2007).

M. Tech. I (Chemical Engineering) – Semester - II ENVIRONMENT MANAGEMENT SYSTEM (CHCH176) Institute Elective	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course the students will be able to:
CO1	Describe, develop and interpret methods of the Environmental Management Systems.
CO2	Justify the need for the knowledge of various environmental protection rules, standards, and EIA guidelines.
CO3	Apply the applications of environmental management systems on different chemical industries.
CO4	Understand the concept of environmental impact assessment
CO5	Implement the Environmental Auditing in various Industries/Projects
CO6	Prepare the post-project monitoring activities

2.	**Syllabus**	
	INTRODUCTION TO ENVIRONMENT MANAGEMENT SYSTEM	**5 Hours**
	Introduction to environment, basic Definitions and terms of environmental management system, framework for environmental management system	
	RESOURCE MANAGEMENT AND SUSTAINABLE DEVELOPMENT	**4 Hours**
	ENVIRONMENTAL PROTECTION ACTS, RULES AND STANDARDS, EIA GUIDELINES	**6 Hours**
	The Water (Prevention and Control of Pollution) Act, Air (Prevention and Control of Pollution) Act, Environmental Protection Act	
	ENVIRONMENT IMPACT ASSESSMENT	**6 Hours**
	Definition and scope, preliminary screening requiring EIA of projects. Impact identification, Assessment of Impact; Impact Evaluation. Types of EIA, rapid and comprehensive, Methods of environment impact assessment	
	ENVIRONMENT MANAGEMENT	**6 Hours**
	Natural Resources Conservation, Conservation of Energy, Pollution prevention, Disposal of Treated effluents, Solid Waste Disposal, Concept of green cities	
	INTRODUCTION TO ENVIRONMENTAL AUDITING	**7 Hours**
	Introduction to Environmental Auditing, Category "A" & "B" types of projects. Procedures and Guidelines to conduct Environmental Audit.	
	APPLICATIONS OF ENVIRONMENTAL MANAGEMENT SYSTEM	**6 Hours**
	Applications EMS in terms of Process flow chart, effluent Generation, composition and treatment of effluents from different chemical industries.	
	POST PROJECT MONITORING	**5 Hours**
	Total Contact Time: 45 Hours	

3.	**Books Recommended**
1	"Environmental Management Systems: An Implementation Guide for Small and Medium-Sized Organizations", 2nd Edition, NSF International, Ann Arbor, Michigan, 2001.
2	M. N. Rao, "Waste Water Treatment", Oxford and IBH publishing Co. Pvt Ltd, 2007.
3	H. S. Peavy, D.R. Rowe, T. George, "Environmental Engineering", New York: McGraw-Hill, 1987.
4	Christopher Sheldon and Mark Yoxon, "Installing Environmental management Systems – a step by step guide", Earthscan Publications Ltd, London, 1999.
5	N. K. Uberoi, "Environmental Management", Excel Book, New Delhi, 2004.

4.	**Additional Reading**
1	Recent literature from Journals on Separations.

M. Tech. I (Chemical Engineering) – Semester - I CHEMICAL ENGINEERING LAB - 1 (CHCH107)	Scheme	L	T	P	Credit
		0	0	04	02

1.	**Course Outcomes (COs):** At the end of the course the students will be able to:
CO1	Understand, explain and select instrumental techniques for analysis
CO2	Analyse and interpret the experimental data based on experiments performed
CO3	Simulate cubic and partial differential equations using computational software
CO4	Adapt simulation software to solve chemical engineering problems
CO5	Solve chemical engineering case studies using computational software

2.	**Syllabus**
	Introduction to analytical experimental methods and sophisticated instruments. Experiments using sonication,microwave radiation, membrane separation, reactors, etc. and analysis using GC, HPLC, UV, DLS, TURBISCAN, Contact Angle measuring instruments. Introduction to the different simulation softwares and their applications to solve the problems arising in chemical engineering systems. Solving different case studies from chemical engineering thermodynamics, heat transfer and fluid flow, mass transfer, and chemical reaction engineering using simulation softwares.

M. Tech. I (Chemical Engineering) – Semester - II CHEMICAL ENGINEERING LAB - 2 (CHCH107)	Scheme	L	T	P	Credit
		0	0	04	02

1.	**Course Outcomes (COs):** At the end of the course the students will be able to:
CO1	Understand, explain and select instrumental techniques for analysis
CO2	Analyse and interpret the experimental data based on experiments performed
CO3	Simulate cubic and partial differential equations using computational software
CO4	Adapt simulation software to solve chemical engineering problems
CO5	Solve chemical engineering case studies using computational software

2.	**Syllabus**
	Introduction to analytical experimental methods and sophisticated instruments. Experiments using sonication, microwave radiation, membrane separation, reactors, etc. and analysis using GC, HPLC, UV, DLS, TURBISCAN, Contact Angle measuring instruments. Introduction to the different simulation softwares and their applications to solve the problems arising in chemical engineering systems. Solving different case studies from chemical engineering thermodynamics, heat transfer and fluid flow, mass transfer, and chemical reaction engineering using simulation softwares.

Teaching and Examination Schemes with Syllabus

of

Master of Technology

in

(Civil) Construction Technology and Management

Department of Civil Engineering

Sardar Vallabhbhai National Institute of Technology, Surat

Vision and Mission of the Institute

Vision

To be one of the leading Technical Institutes disseminating globally acceptable education, effective industrial training and relevant research output

Mission

To be a globally accepted center of excellence in technical education catalyzing absorption, innovation, diffusion and transfer of high technologies resulting in enhanced quality for all the stake holders

Vision and Mission of the Department

Vision

To be a global centre of excellence for creating competent professionals in Civil Engineering

Mission

- To provide excellent education producing technically competent, globally employable civil engineers who will be leaders in the chosen field
- To undertake research in conventional and advanced technologies fulfilling the needs and challenges of modern society
- To provide consultancy services and develop partnerships with society, industry and public organizations.
- To organize seminar, conferences, symposia and continuing education programmes for academic and field community.

Foreword

Sardar Vallabhbhai National Institute of Technology (SVNIT), Surat was established in the year 1961 and the Construction Technology and Management (CTM) Section began its journey since 2020. The postgraduate course in CTM is designed to meet the present and the future challenges of construction sector and to explore and apply various construction technologies in execution of projects. It aims to develop the managerial and leadership skill of students to deliver the project in time and assigned budget with ensuring quality, safety, and environment surrounding of the project. The yearly intake of PG program of CTM is 30. Out of this, 25 with scholarships are filled up through Centralized Counselling for M Tech (CCMT) based on GATE score and five sponsored category seats are based on their experience and merit. Before commencement of this PG program, its curriculum was designed and formulated through a brainstorming workshop in 2018 in presence of domain experts from academia, research and development organizations, alumni, and field professionals. The curriculum includes core courses, multi-disciplinary electives, practical, training, seminars and dissertation. The subjects and their contents have carefully been developed. This CTM section has also benefits of various visiting professors and professional experts. The section organizes various expert lectures and site visits from time to time as an integral part of the study. The section has enough infrastructure and laboratories. The section is actively involved in basic and applied research and consultancy services. It has strong research and academic ties with various IITs, NITs, and NCCS of the University of Kansas, USA, London South Bank University, University of Salford, ICHR, AHRC UK, and MoRTH. Many construction companies including L&T, Linde Engineering, AFCON, Tata Projects, KEC, Rail Tech, Federal Bank, GMRC, NHRCL, etc., have recruited and provided internships to students in their projects. We welcome you to visit our section and institute and to explore the opportunity of working together.

Programme Educational Objectives (PEOs)

The graduates of the M. Tech. Construction Technology and Management Programme will:

- Foster their professional career and managerial skill in construction and development of projects.
- Exhibit professionalism through lifelong learning and able to work in teams for collaborative and various task.
- Manifest professionalism, ethical approach, leadership, application of new technology, communication skills, team work in their profession and adapt to modern trends by engaging in lifelong learning.

Programme Outcomes (POs)

The outcomes of the Master of Technology programme in Construction Technology and Management are:

- An ability to independently carry out research /investigation and development work to solve practical problems.
- An ability to write and present a substantial technical report/document.
- Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate Master program.

Programme Specific Outcomes (PSOs)

- Acquire thorough knowledge of Construction Technology and Management to analyze the complex problems and evaluate them over a wide range of feasible and economic solutions by applying the advanced tools, techniques, technology, and latest softwares in order to meet the needs of the society with due consideration of sustainability, quality and safety.
- Conceptualize and solve problems of construction projects, evaluate wide range of potential solutions and arrive at feasible and optimal solutions to meet the needs of the society with respect to safety, economy, legal and environmental considerations.
- Contribute positively to collaborative – multidisciplinary scientific research demonstrating capacity for self-management and teamwork, decision making based on open-mindedness, objectivity using knowledge of group dynamics to achieve common goals of advancement in learning for self and others.

Teaching Scheme
M.Tech. in (Civil) Construction Technology and Management

Sr. No.	Subject	Code	Scheme L-T-P	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
				Th.	T	P		
				Marks	Marks	Marks		
	First Semester							
1	Construction Project Planning and Control	CECT101	3-1-0	100	25	-	4	70
2	Construction Methods and Equipment	CECT103	3-1-0	100	25	-	4	70
3	Project Appraisal and Finance	CECT105	3-1-0	100	25	-	4	70
4	Core Elective – 1	CE##1XX	3-0-0	100	-	-	3	55
5	Core Elective – 2	CE##1XX	3-0-0	100	-	-	3	55
6	Construction Management Lab	CECT107	0-0-4	-	-	100	2	70
						Total	**20**	**390**
8	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	CECTV01 CECTP01	0-0-10				5	200 (20 x 10)
	Second Semester							
1	Construction Contract and Law	CECT102	3-1-0	100	25	-	4	70
2	Construction Quality and Safety	CECT104	3-1-0	100	25	-	4	70
3	Core Elective - 3	CE##1XX	3-0-0	100	-	-	3	55
4	Core Elective - 4	CE##1XX	3-0-0	100	-	-	3	55
5	Institute Elective*	CE##1XX	3-0-0	100	-	-	3	55
6	Industry 4.0 Lab	CECT106	0-0-4	-	-	100	2	70
7	Mini Project	CECT108	0-0-2	-	-	50	1	40
						Total	**20**	**415**
8	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	CECTV02 CECTP02	0-0-10				5	200 (20 x 10)
	Third Semester							
1	Summer Training	CECT201	-	-	-	100	2	-
2	MOOC course – I*	Φ	-	-	-	-	3/4	70/80
3	MOOC course – II*	Φ	-	-	-	-	3/4	70/80
4	Dissertation Preliminaries	CECT295	-	-	-	350$	14	560
						Total	**22-24**	**700-720**
	Fourth Semester							
1	Dissertation	CECT296	-	-	-	600$	20	800

$ **Internal**: 40% and **External**: 60% ;

*Swayam/NPTEL;

φ As per 66th IAAC, Dated 20th March, 2024, Resolution No. 66.34 and 61st Senate resolution No. 4, 25th April, 2024

Sr. No.	Core Elective - 1	Code	Scheme L-T-P
1	Design of Formwork Systems	CECT111	3-0-0
2	Low-Cost Construction	CECT113	3-0-0
3	Building Services and Management	CECT115	3-0-0
4	Lean Construction	CECT117	3-0-0
5	Railways Infrastructure Planning and Design	CETP117	3-0-0
6	Geospatial Techniques	CEUP117	3-0-0
7	Real Estate Management	CEUP125	3-0-0
8	Water Supply Distribution Systems	CEWR115	3-0-0

Sr. No.	Core Elective - 2	Code	Scheme L-T-P
1	Advanced Construction Materials	CECT119	3-0-0
2	Organization Management	CECT121	3-0-0
3	Plumbing Engineering	CECT123	3-0-0
4	Demolition of Structures	CECT125	3-0-0
5	Research Analytical Methods	CETP101	3-1-2
6	Airport Infrastructure Planning and Design	CETP116	3-0-0
7	Waterways Infrastructure Planning and Design	CETP119	3-0-0

Sr. No.	Core Elective - 3	Code	Scheme L-T-P
1	Precast and Prestressed Construction	CECT112	3-0-0
2	Building Information Modelling (BIM)	CECT114	3-0-0
3	Real Estate Valuation	CECT116	3-0-0
4	Environmental Legislation and Impact Assessment	CEEN111	3-0-0
5	Applied Statistics for Engineers	CEEN120	3-0-0
6	Ground Improvement Techniques	CEGT201	3-1-0
7	Road Safety and Environment	CETP126	3-0-0
8	Urban Infrastructure Planning	CEUP102	3-0-0

Sr. No.	Core Elective - 4	Code	Scheme L-T-P
1	Disaster Risk and Resilience	CECT118	3-0-0
2	Maintenance and Rehabilitation	CECT120	3-0-0
3	Heritage Conservation and Management	CECT122	3-0-0

4	Introduction to Internet of Things (IOT)	CECT124	3-0-0
5	Masonry Design	CECT126	3-0-0
6	Tunnelling and Underground Structures	CEGT221	3-0-0
7	Operation and Maintenance Management of Pavements	CETP127	3-0-0

Sr. No.	Institute Elective offered by CTM Section	Code	Scheme L-T-P
1	AI/ML based Applications in Civil Engineering	CECS175	3-0-0
2	Project Management for Engineers	CECT172	3-0-0
3	Project Appraisal and Finance	CECT174	3-0-0
4	Offshore and Marine Projects Management	CECT176	3-0-0
5	Quantitative Methods	CECT178	3-0-0
6	Resilient and Sustainable Infrastructure	CECT180	3-0-0
7	Smart Infrastructure System	CECT182	3-0-0
8	Building Information Modelling (BIM)	CECT184	3-0-0

*Code of Subjects may be changed later on.

Allotment of elective

The choice of the elective courses is primarily based on the interest of the students. Faculties offering the respective elective subject interact with all students and brief out the content with relevance of the subject in field or in research. On the basis of merit, students are given the freedom to select the elective of their choice. Emphasize is made to offer maximum number of electives in each semester, however, at least 6 students need to opt a certain elective to run it.

Assessment of Performance

Assessment of Theory Courses

The evaluation pattern for the theory courses, *as of now*, shall be as under:

Mid-semester examination: 30 marks

Assignment/Quizzes: 20 marks

Tutorials (if applicable): 25 marks

End-semester exam: 50 marks

The mid-semester and end-semester examinations are of 1.5 hours and 3 hours, respectively.

For more details please refer to the institute website

https://www.svnit.ac.in/Data/Notice/AcademicRegulations2013-2014.pdf

Course-wise Detailed Syllabus

Semester I

CECT101 Construction Project Planning and Control

L	T	P	C
3	1	0	4

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Comprehend the basic principles of construction project, its complexity and its management.
CO2	Prepare work breakdown structure and find out the tasks necessary for activity completion.
CO3	Plan and apprehend the concepts and principles of project pre-construction, construction and post-construction phases.
CO4	Understand and demonstrate conventional as well as advanced principles and techniques of construction planning, scheduling and controlling.
CO5	Evaluate interrelationships between project time, cost, quality and performance.

2. Syllabus

- **CONCEPT OF PROJECT MANAGEMENT** **(12 Hours)**
  Conception to closing- a life cycle approach stakeholders in projects, initiation, planning, execution, monitoring and control, and closing, approach to realistic cost estimation, bid document preparation and significance of its each segment, bidding stage assumptions and factors influencing project performance, iron triangle project scope, time and cost, project strategy, project feasibility, demonstration of practical applications through case studies.

- **WORK BREAKDOWN STRUCTURE** **(11 Hours)**
  Scope management, project charter, scope of work (SOW), concept of WBS, quality principles, typical hierarchy in the WBS of a project, desirable characteristic of work packages, determinants having critical influences on the work packages, scope creep, change management, WBS, OBS and RBS, control accounts.

- **PROJECT PLANNING AND SCHEDULING** **(12 Hours)**
  Importance of sound planning, scheduling, principles and techniques, scheduling methods (AOA and AON), critical path method, concept of float, project evaluation

and review techniques, line of balance variances in project duration and cost, network scheduling with limited resources, resource allocation, smoothing and levelling, updating the network, master networks, time-cost trade-off approach, progress review and reporting, risk of schedule delays, missing milestone deliverables and its impact (from client and contractors view point) change management, contemporaneous records, documenting delays and maintaining records, material management.

- **PROJECT CONTROL AND MONITORING (10 Hours)**
  Parameters of project performance, time, cost and quality and their interrelationships, schedule and cost control tools and techniques, performance reporting, audit, corrective and preventive actions, fund flow control, management information system and application of management software, demonstration of practical applications through case studies.

(Total Lectures: 45 hours. Tutorial: 15 hours)

3. References

1. Harris, F., McCaffer, R., Baldwin, A., & Edum-Fotwe, F. (2021). *Modern construction management*. John Wiley & Sons.
2. Fewings, P., & Henjewele, C. (2019). *Construction project management: an integrated approach*. Routledge.
3. Mubarak, S. A. (2015). *Construction project scheduling and control*. John Wiley & Sons.
4. Jha, K. N. (2015). *Construction Project Management*. 2nd Edition. Pearson Publishers.
5. Goetsch, D. L. (2014). *Project management for construction*. Pearson Higher Ed.
6. Baldwin, A., & Bordoli, D. (2014). *Handbook for construction planning and scheduling*. John Wiley & Sons.
7. Whyte, A. (2014). *Integrated design and cost management for civil engineers*. CRC Press.
8. Ottosson, H. (2012). *Practical project management for building and construction*. CRC Press.
9. Schexnayder, C. J., & Mayo, R. E. (2008). *Construction management fundamentals*. McGraw-Hill Professional. .

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	3	3	3	2	1
CO2	2	3	2	3	2	1
CO3	3	3	3	3	1	1
CO4	3	3	3	3	2	2
CO5	2	2	3	3	3	1

1-Low 2-Moderate 3-High

CECT103 Construction Methods and Equipment

L	T	P	C
3	1	0	4

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Understand different formwork systems and temporary structures.
CO2	Learn in depth about steel and pre-stressed construction.
CO3	Perceive heavy and special construction techniques.
CO4	Perform technical and economic analysis of different construction equipments.
CO5	Judge appropriate selection of construction equipment.

2. Syllabus

- **TEMPORARY STRUCTURES** **(06 Hours)**

  Temporary structures including formwork, scaffolding, shoring, underpinning, various kinds of slip forms, reshoring, and back shoring in multistorey building construction.

- **STEEL CONSTRUCTION** **(06 Hours)**

  Planning and principles of steel structural frames, structural steel frame components, connecting structural steel sections, structural steel fabrication, structural steel site work and erection.

- **PRESTRESSING AND COMPOSITE CONSTRUCTION METHODS** **(07 Hours)**

  Different types of prestressing systems, methods of post-tensioning and pre-tensioning, prefab construction, modular coordination.

- **SPECIAL CONSTRUCTION METHODS** **(10 Hours)**

  Bridge construction including segmental construction, incremental construction and push launching techniques, box pushing method, different types of tunnel construction methods

- **PLANNING AND SELECTION OF CONSTRUCTION EQUIPMENT** **(10 Hours)**

  Factors affecting selection of equipment - technical and economic, analysis of production outputs and costs, different types of depreciation methods, characteristics and performances of equipment for major civil engineering activities such as earth moving, erection, material transport, pile driving, dewatering, and concreting, ready mix concrete plants.

(Total Lectures: 45 hours. Tutorial: 15 hours)

3. References

1. Andres, C. K., Smith, R. C., & Woods, W. R. (2018). *Principles and practices of commercial construction*. Pearson/Prentice Hall.
2. Peurifoy, Robert L., Clifford J. Schexnayder, Robert L. Schmitt, & Aviad Shapira. (2018). *Construction Planning, Equipment, and Methods*. 9th ed. New York: McGraw-Hill Education
3. Jha, K. N. (2015). *Construction Project Management: Theory and Practice*. Second Edition, Pearson Publishers.
4. Benhart, R. R. (2015). *Construction site planning and logistical operations*. Purdue University Press, West Lafayette, United States.
5. Jha, K. N. (2012). *Formwork for Concrete Structures*, Tata McGraw Hill Publishers.
6. Najafi, M. (2012). *Trenchless technology: Planning, equipment, and methods*. McGraw Hill Professional.
7. Chudley, R., & Greeno, R. (2006). *Advanced construction technology*. Pearson Education.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	2	3	1	1	1
CO2	2	3	3	2	2	2
CO3	2	2	2	2	3	2
CO4	2	2	3	2	1	2
CO5	2	3	3	2	1	2

1-Low 2-Moderate 3-High

CECT105 Project Appraisal and Finance

L	T	P	C
3	1	0	4

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Learn the basics of measurement of project performance.
CO2	Understand the various discounting and compounding criteria.
CO3	Familiarize with accounting fundamentals.
CO4	Study the theories of working capital management.
CO5	Apply financial methods in making capital investment decisions in projects.

2. Syllabus

- **PROJECT FORMULATION** **(10 Hours)**

  Generation and screening of project ideas, project identification, preliminary analysis, market, technical, financial, economic, and ecological pre-feasibility report, and its clearance, project estimates and techno-economic feasibility report, detailed project report, different project clearances required.

- **PROJECT APPRAISAL** **(10 Hours)**

  NPV, BCR, IRR, ARR, urgency-payback period, assessment of various methods, Indian practice of investment appraisal, international practice of appraisal, analysis of risk, different methods for selection of a project and risk analysis in practice, ownership structures; BOT, BOLT, BOOT models.

- **PROJECT ACCOUNTING** **(09 Hours)**

  Profit and loss, balance sheet, income statement, ratio analysis, depreciation and amortization, preparation of financial statements, inflation accounting, and corporate practices in India.

- **WORKING CAPITAL MANAGEMENT** **(08 Hours)**

  Policy for working capital, estimating working capital need, inventory management, accounts receivable, credit and cash management, managing payments to supplies and outstanding, capital investment decisions, techniques of capital budgeting, cost of capital, cash flow analysis.

- **LONG TERM FINANCING AND BUDGETING** **(08 Hours)**

  Working in financial institutes in India and abroad, self-financing, stock exchanges, types of securities, borrowings, debentures, types of budgeting, procedure for master budget, key factor, budget manual, and new approach to budgeting, cash flow forecast.

(Total Lectures: 45 hours. Tutorial: 15 hours)

3. References

1. Pandey, I. M. (2021). *Financial Management*. 12th edition, Pearson.
2. Khan, M. Y., Jain, P. K. (2018). *Financial Management*. TataMcGraw-Hill Publishing Company Limited.
3. Desai, V. & Kaur K. (2015). *Entrepreneurship: Development and Management*. Himalaya Publishing House.
4. Desai, V. (2011). *Dynamics of entrepreneurial development and management* (pp. 119-134). Himalaya Publishing House.
5. Maheshwari, S. N. (2002). *Cost and Management Accounting*. Sultan Chand.
6. Chandra, P. (1987). *Projects: preparation, appraisal, budgeting and implementation*. Tata McGraw-Hill Publishing Company Limited.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	2	2	2	2
CO2	2	2	1	2	2	2
CO3	3	2	3	3	2	2
CO4	3	2	2	3	1	2
CO5	3	2	2	3	2	2

1-Low 2-Moderate 3-High

CORE ELECTIVE – 1

CECT111 Design of Formwork Systems

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Illustrate the requirement of formwork; classify the formwork systems and their selection; and choose the appropriate material.
CO2	Determine the expected loads on formwork systems and calculate the permissible values.
CO3	Design of formwork systems for the construction of various structural members.
CO4	Analysis of load distribution on shores and slabs in multi-story building frames.
CO5	Learn the causes of formwork failures and their preventive measures; study the applications of various special formwork.

2. Syllabus

- **INTRODUCTION** **(06 Hours)**
  Formwork and falsework, requirement of formwork; selection of formwork; classifications of formwork, materials for formwork

- **FORMWORK DESIGN CONCEPTS** **(03 Hours)**
  Loads on formwork systems, design aspects and assumptions, permissible stresses and deflections as per IS codes

- **FORMWORK FOR FOUNDATION AND WALLS** **(08 Hours)**
  Various components of formwork for foundations and walls and their design, proprietary wall formwork systems

- **FORMWORK FOR COLUMNS** **(05 Hours)**
  Various components of formwork for columns and their design, proprietary column formwork systems, disposable column formwork

- **FORMWORK FOR BEAMS AND SLABS** **(08 Hours)**
  Various components of formwork for beams and slabs and their design; proprietary beam and slab formwork systems

- **FORMWORK IN MULTI-STORY BUILDING CONSTRUCTION** **(08 Hours)**
  Shoring, reshoring, back-shoring and pre-shoring, striking and cycle time, simplified

analysis and their assumptions and limitations, load distribution on shores and slabs in multi-story building frames, calculating the strength of the concrete slab at a given point in time

- **FORMWORK FAILURES** **(02 Hours)**
  Causes of formwork failures, deficiencies in designing, preventive measures, safety in formwork operations

- **SPECIAL FORMWORK** **(05 Hours)**
  Flying formwork: table forms, tunnel formwork, column-mounted shoring systems, gang forms; slip formwork, formwork for precast concrete; formwork for bridge structures

(Total Lectures: 45 hours)

3. References

1. Jha, K.N. (2017). *Formwork for concrete structures.* McGraw Hill Publishers.
2. Peurifoy, L. R., & Oberlender, D. G. (2011). *Formwork for Concrete Structures 4th edition*. The McGraw-Hill Companies.
3. IS 883 (2005). *Design of Structural Timber in Building- Code of Practice*. Bureau of Indian Standards.
4. IS 14687 (2005). *Falsework for concrete structures - Guidelines*, Bureau of Indian Standards.
5. IS 4990 (2003). *Plywood for concrete shuttering work – Specification*. Bureau of Indian Standards.
6. IS 875 (Parts 1-3). (2003). *Code of practice for design loads (other than earthquake) for buildings and structures: Dead loads*. Bureau of Indian Standards.
7. Hanna, A. S. (1998). *Concrete formwork systems*. CRC Press.
8. IS 1161 (1998). *Steel tubes for structural purposes – Specification*. Bureau of Indian Standards.
9. *Guidelines for the design and erection of falsework for road bridges*. (1984). The Indian Road Congress, New Delhi.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	3	3	3	3
CO2	3	1	3	2	2	1
CO3	3	2	3	3	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	2

1-Low 2-Moderate 3-High

CORE ELECTIVE – 1

CECT113 Low Cost Construction

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Comprehend the aspects of low cost and sustainable infrastructure development.
CO2	Identify the cost-effective materials for the infrastructure development projects.
CO3	Illustrate the applicability of low-cost techniques and equipment in construction projects.
CO4	Apply the low-cost methods for wastewater disposal systems and sanitation in rural and urban areas.
CO5	Evaluate the cost benefits of using low-cost methods in construction projects.

2. Syllabus

- **CONCEPTS OF LOW-COST MATERIALS (06 Hours)**

  Soil, fly ash, ferro cement, lime, fibers, stone dust, boulders and oversize metal, bitumen etc.

- **LOW-COST BUILDING MATERIAL PRODUCTS (12 Hours)**

  Walls, stabilized and sun dried, soil blocks and bricks, hollow concrete blocks, stone masonry blocks, ferro cement partitions, Roofs, precast r.c. plank and joists roof, precast channel roof, precast l-panel roof, precast funicular shells, Ferro cement shells, filler slab, seasonal fiber roof, improved country tiles, and thatch roof.

- **LOW-COST CONSTRUCTION TECHNIQUES AND EQUIPMENT (10 Hours)**

  Techniques, rat trap bond construction, precast r.c. and ferro cement technique, mud technology, equipment, brick molding machine, stabilized soil block making machine and plants for the manufacturing of concrete blocks, low-cost roads.

- **LOW-COST SANITATION (08 Hours)**

  Waste water disposal system, low-cost sanitation for rural and urban areas, ferro cement drains.

- **COST ANALYSIS AND COMPARISON (09 Hours)**

  Low-cost materials, Low-cost techniques.

3. References **(Total Lectures: 45 hours)**

1. Holm, L., & Schaufelberger, J. E. (2021). *Construction cost estimating*. Routledge.
2. Jain, A. K. (2016). *Housing for all*. Khanna Publishing House.
3. Ruiz, F. P. (2005). *Building an Affordable House: Trade Secrets to High-value, Low-cost Construction*. Taunton Press.
4. Lal, A. K. (1996). *Hand book of low cost housing*. New Age International.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	1	1	1	1	1
CO2	2	1	2	2	1	2
CO3	2	2	2	2	2	3
CO4	2	2	2	1	1	3
CO5	3	3	3	2	3	3

1-Low 2-Moderate 3-High

CORE ELECTIVE – 1

CECT115 Building Services and Management

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Learn management of building services provisions in construction sites.
CO2	Identify the building services for the requisite functional needs.
CO3	Estimate space requirements for vertical transportation services.
CO4	Execute relevant system of heating, ventilation and air conditioning for buildings.
CO5	Study the role and strategies of building maintenance in construction process.

2. Syllabus

- **FIRE PROTECTION SYSTEM** **(12 Hours)**

  Fire protection: process of combustion in fire, effect of fire load and ventilation condition on enclosure fire, growth and decay of fire in enclosure, concepts of fire resistant and severity, effect of fire on materials. design of elements for given fire resistance, structural fire protection, site planning, internal planning for escape and refuges, fire detection and suppression systems, smoke venting.

- **VERTICAL TRANSPORTATION AND HVAC** **(12 Hours)**

  Lifts and vertical transportation: arrangement of lifts and design for optimum service condition, HVAC system: design consideration. basic psychrometry, air conditioning process and system. methods of air conditioning, problems.

- **ELECTRICAL SYSTEM** **(10 Hours)**

  Element of electrical services in building, illumination and intelligent building.

- **MAINTENANCE AND REPAIR STRATEGIES** **(11 Hours)**

  Element of electrical services in building, illumination and intelligent building, definition, role of building maintenance in construction process maintenance generators, expression of standards, selection of level of maintenance and fixing standards, maintenance cycle, maintenance profile, repair and replacement models, statistical methods, decision models, optimal renewal cycle, budgeting etc.

(Total Lectures: 45 hours)

3. References

1. Buchanan, A. H., & Abu, A. K. (2017). *Structural design for fire safety*. John Wiley & Sons.
2. Purkiss, J. A., & Li, L. Y. (2013). *Fire safety engineering design of structures*. CRC press.
3. Merritt, F. S. (2012). *Building engineering and systems design*. Springer Science & Business Media.
4. Drysdale, D. (2011). *An introduction to fire dynamics*. John Wiley & sons.
5. Chanter, B., & Swallow, P. (2008). *Building maintenance management*. John Wiley & Sons.
6. Croome, D. J., & Roberts, B. M. (1981). *Airconditioning and ventilation of buildings*. Pergamon Press.
7. Markus, T. A., & Morris, E. N. (1980). *Buildings, climate, and energy.* Pitman Publishing.
8. National Building Code Part 4. (2016) – Fire and Life Safety, BIS, New Delhi.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	2	3	3	3	2
CO2	3	2	2	3	2	1
CO3	3	2	2	3	2	1
CO4	3	2	2	3	2	1
CO5	3	3	1	2	3	2

1-Low 2-Moderate 3-High

CORE ELECTIVE – 1

CECT117 Lean Construction

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Learn the fundamentals and origin of lean construction.
CO2	Study different lean construction practices, tools and methods.
CO3	Explore the purpose and role of value management job plan.
CO4	Understand the basics of life cycle costing and cost estimation systems.
CO5	Recognize various methods of valuation used in practice.

2. Syllabus

- **LEAN CONCEPT AND PRINCIPLES** **(06 Hours)**
  History, basic approach, definitions, lean philosophy, role of value engineering and management, effect of cost on design parameters, purpose and application to construction industry, application to design, market value.

- **VALUE MANAGEMENT JOB PLAN** **(03 Hours)**
  Role and purpose of VM job plan, steps of VM job plan, general phase, project selection phase, information phase, functional phase, judicial phase, evaluation phase, recommendation phase and implementation phase.

- **FUNCTIONAL ANALYSIS** **(08 Hours)**
  Functions, relationship, function analysis systems technique (FAST), application in value management, improvement in systems.

- **LIFE CYCLE COSTING** **(05 Hours)**
  Life cycle cost elements; LCC logic, application to facilities, analysis of the total cost of ownership, escalation and its impact, cost analysis concepts, cost matrix in LCC analysis.

- **COSTING AND COSTING MODELING** **(08 Hours)**
  Cost estimation system; use of cost models; establishing cost targets; objectives of costing; cost target team and organization; classification of costs based on complexity; datum creation; matrix and functional cost model; quality cost model, equipment cost

model, billing cost model.

- **METHODS OF VALUATION** **(08 Hours)**

  Rental method: essential ingredients, forms of rent, year purchase, capitalized value, shares and debentures, bonds of gilt-edged securities, life of structures, case studies in the rental method of evaluation. land and building method: cost of construction, estimate on area basis, estimate on cubic basis, estimate by cost index, residual or demolition value of old building and case studies, profit method of valuation with case studies.

(Total Lectures: 45 hours)

3. References

1. Anil Kumar, M. (2003). *Value Engineering: Concept, Technique and Application*. SAGE Publishers.
2. Koskela, L. (1999). *Management of Production in Construction: A Theoretical View*. Proc. 7th Annual Conference of the International Group for Lean Construction (IGLC 7) Berkeley.
3. Howell, G. A. (1999). *What is Lean Construction*, Proc. 7th Annual Conference of the International Group for Lean Construction (IGLC 7), Berkeley, CA, 1-10.
4. Namavati, H R. (1998). *Theory and Practice of Valuation*. Lakhani Book Depot.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	1
CO2	2	3	2	3	2	2
CO3	2	2	2	3	3	1
CO4	3	2	3	3	3	2
CO5	3	3	2	2	3	1

1-Low 2-Moderate 3-High

CORE ELECTIVE – 1

CETP117 Railways Infrastructure Planning and Design

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Identify the Components of Railway Track, different Railway Gauges.
CO2	Design track Gradients as per given requirements and Discuss various Types of Track Turnouts.
CO3	Describe purposes and facilities at Railway Stations.
CO4	Understanding Interlocking and modern signal system.
CO5	Describe Surface Defects on Railway Track and Their Remedial Measures.

2. Syllabus

- **PLANNING OF RAILWAY LINES NETWORK (05 Hours)**
  Railways operational system, historical background of Indian railways, plans and developments, policy and standards, traffic forecast and surveys, railway alignment, project appraisal, and organization setup.

- **COMPONENT OF RAILWAY TRACK AND ROLLING STOCK (06 Hours)**
  Permanent way, forces acting, rails, the function of rails, rail fixtures and fastenings, sleepers and ballast, rail joints, elements of junctions and layouts, types of traction, locomotives and other rolling stock, brake systems, resistance due to friction, wave action, wind, gradient, curvature, starting, tractive effort of a locomotive, hauling power of a locomotive.

- **GEOMETRIC DESIGN OF RAILWAY TRACK (08 Hours)**
  Right of way and formation, field investigation, geometric design elements, safe speed on curves, speeds computation, string lining of curves, gradients, grade compensation, railway cant and cant deficiency, traction.

- **TRACK CONSTRUCTION (06 Hours)**
  Special considerations and construction practices, track laying, Introduction of the maintenance programme, Monsoon, Pre-Monsoon and Post-Monsoon Maintenance, Causes for Maintenance, Routine Maintenance, Tools for Railway Track Maintenance and Their Functions, Surface Defects and Their Remedial Measures, track drainage,

track circuited lengths, track tolerances, mechanized method, off-track tampers, shovel packing, ballast confinement and directed track maintenance, bridge maintenance, renewal, classification of renewal works, through sleeper renewals, mechanized relaying, track renewal trains.

- **SIGNALING AND INTERLOCKING** **(04 Hours)**
  Objectives, classification, fixed signals, stop signals, signaling systems, mechanical signaling systems, electrical signaling systems, systems for controlling train movement, interlocking, and modern signaling installations.

- **RAILWAY ACCIDENTS AND SAFETY** **(06 Hours)**
  Train accidents, collision and derailments and their causes, restoration of traffic, safety measures, disaster management, classification of level crossings, accidents at level crossings, remedial measures, and maintenance of level crossings

- **RAILWAY STATION AND YARDS** **(06 Hours)**
  Site selection, facilities, classification, platforms, building areas, types of yards, catch sidings, ship sidings, foot over bridges, subways, cranes, weighbridge, loading gauge, end loading ramps, locomotive sheds, ash-pits, water columns, turntable, triangles, traverser, carriage washing platforms, buffer stop, scotch block, derailing switch, sand hump, fouling mark.

- **HIGH-SPEEDED RAILWAYS** **(04 Hours)**
  Modernization of railways, the effect of high-speed track, vehicle performance on track, high-speed ground transportation system, ballastless track, track requirement for bullet trains, elevated railways, underground and tube railways.

(Total Lectures: 45 hours)

3. References

1. Chandra, S. & Agrawal, M.M. (2013). *Railway Engineering*. Oxford University Press India.
2. Saxena, S. C., & Arora, S. P. (2004). *A text book of railway engineering*. 7th Edition. Dhanpat Rai Publications (p) Ltd, New Delhi.
3. Rangwala, S.C. (1988). *Principles of Railway Engineering*. Charotar Publishing House.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	3	2	2	1
CO2	3	2	2	1	2	2
CO3	2	2	3	1	1	1
CO4	2	3	2	2	2	3
CO5	3	2	2	2	1	2

1-Low 2-Moderate 3-High

CORE ELECTIVE – 1

CEUP117 Geospatial Techniques

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Summarize various techniques of data acquisition.
CO2	Classify different data structures of remote sensing, GIS and GPS.
CO3	Analyze images based on supervised and unsupervised techniques.
CO4	Generate GIS database model using software.
CO5	Use spatial data analysis techniques for Urban Planning applications.

2. Syllabus

- **INTRODUCTION (02 Hours)**
  Introduction to GIS, remote sensing and GPS, applications in various fields of engineering and planning.

- **CONCEPTS AND FUNDAMENTALS OF REMOTE SENSING (08 Hours)**
  Basics of aerial and satellite remote sensing, components of remote sensing, principles of remote sensing, energy sources, electromagnetic radiation (EMR), electromagnetic spectrum, energy interactions, active and passive remote sensing, data acquisition, remote sensing platforms, satellites, sensors.

- **IMAGE INTERPRETATION AND DIGITAL IMAGE PROCESSING (08 Hours)**
  Fundamentals of air photo interpretation, keys, elements of air photo interpretation for terrain evaluation. digital image processing, image enhancement, supervised and unsupervised analysis, classification and analysis, and ground truth.

- **STRUCTURE OF GIS (08 Hours)**
  Cartography, geographic mapping process, transformations, map projections, geospatial and geomatics data, geographic data representation, storage, quality and standards of data, database management systems, raster and vector data representation, assessment of data quality, managing data errors.

- **GIS DATA PROCESSING, ANALYSING, AND MODELLING (08 Hours)**
  Raster and vector-based data processing, queries, spatial analysis, quadrant counts,

nearest neighbour analysis, network analysis, surface modeling, DTM, case studies of GIS applications.

- **GLOBAL POSITIONING SYSTEM** **(04 Hours)**
  Concept, components of GPS, GPS setup, accessories, segments-satellites and receivers, case studies of GPS applications.

- **INTEGRATED APPLICATIONS** **(03 Hours)**
  Case studies of Integrated application of RS, GIS and GPS in the field of urban planning and regional planning, water resources, environmental studies, transportation engineering and other civil engineering fields.

- **INTRODUCTION TO SOFTWARE (QGIS/ARCGIS)** **(04 Hours)**
  Introduction to the software and its interface, setting up coordinates, georeferencing, Basic drafting tools, filling up attributes, plotting of maps etc.

(Total Lectures: 45 hours)

3. References

1. DeMers M.N. (2008). *Fundamentals of Geographic Information Systems*. 4th ed, John Wiley and Sons, New York.
2. Reddy A. (2008). *Remote Sensing and Geographical Information Systems*. B.S. Publications, Hyderabad
3. Lo C.P. & Yeung A.K.W. (2006). *Concepts and Techniques of Geographic Information Systems*. 2nd ed, Prentice Hall of India, New Delhi.
4. Kennedy M. (2002). *The Global Positioning System and GIS: An Introduction*. 2nd ed, Ann Arbor Press.
5. Clarke, K. (2001). *Getting Started with Geographic Information Systems*. Prentice Hall, New Jersey.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	0	0	2	2	1
CO2	1	1	2	1	2	1
CO3	3	2	2	1	2	1
CO4	3	2	3	1	2	1
CO5	3	3	3	1	1	2

1-Low 2-Moderate 3-High

CORE ELECTIVE – 1

CEUP125 Real Estate Management

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Understand the concept and principles of real estate sector.
CO2	Identify the role of urban building industry.
CO3	Review urban land policy and its direct government action, legal and physical controls.
CO4	Explain the role of real estate in Urban growth and land dynamics.
CO5	Identify legal aspects of real estate development.

2. Syllabus

- **REAL ESTATE** **(15 Hours)**

  Terminology land documentation, land revenue records, document registration, city survey record, land registration process, property card, index concepts and characteristics; urban real estate market problems, factors affecting real estate property, rights and interests; contract law and real estate; speculation in urban land; betterment and worsening.

- **ECONOMICS AND LOCATION MODELLING** **(16 Hours)**

  Factors affecting different land uses such as residential, commercial, industrial, public and semi-public; land value – concept and factors affecting; rent and modern theory of rent; macro and micro approaches of location such as trade-off model and environment preference model.

- **URBAN LAND POLICY** **(14 Hours)**

  Contents, importance, objectives, measures, instruments for its implementation, direct Govt. action, legal and physical controls; relationship between economic trends, land market and urban development.

  Modern Methods for Land Pooling; PPP Method for Land Pooling; Issues and strategies for Land Management.

(Total Lectures: 45 hours)

3. References

1. Ratcliffe, J., Stubbs, M., & Keeping, M. (2021). *Urban planning and real estate development*. Routledge.
2. Haynes, B.P. (2017). *Corporate Real Estate Asset Management: Strategy and Implementation.* Routledge.
3. Singh, B. (2011). *Urban Infrastructure and Real Estate Management*. Surendra Publications.
4. Paul, B.N. (1997). *Urban Land Economics. London*. The McMillan Press.
5. Lean, W. (1982). *Aspects of Land use Planning. New Jersey*. Gonthic Publications.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	0	0	0	3	2	3
CO2	1	0	1	3	2	2
CO3	1	2	2	3	3	3
CO4	2	1	1	2	1	2
CO5	2	2	2	2	3	3

1-Low 2-Moderate 3-High

CORE ELECTIVE – 1

CEWR115 Water Supply Distribution Systems

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Identify different intake structures and water treatment processes.
CO2	Understand parameters involved in design of water distribution system.
CO3	Design water distribution system.
CO4	Optimize water distribution system.
CO5	Analyze surge in the pressurized water supply network.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**

  Introduction to intake structure, water quality, hydraulics of water treatment processes.

- **TYPE OF DISTRIBUTION SYSTEMS** **(08 Hours)**

  Equivalent pipe, parameters in distribution system analysis, parameters interrelationship, formulation of equation, gravity and rising main, location and design principles.

- **ANALYSIS OF WATER DISTRIBUTION SYSTEMS** **(10 Hours)**

  Methods of analysis: (i) hardy-cross method (ii) newton-raphson method and (iii) linear theory method (iv) gradient method.

- **DESIGN AND OPTIMIZATION OF WATER DISTRIBUTION SYSTEMS** **(13 Hours)**

  Design: trial and error method of design, cost-head loss ratio method. optimization using linear programming techniques, surge analysis in water distribution systems, pump duty stations and detailing valves, pressure transients in pipe flow.

- **CASE STUDIES** **(10 Hours)**

  Case studies on new water distribution Systems, rehabilitation systems, DPR preparation of a water supply system including operation and maintenance through SCADA.

(Total Lectures: 45 hours)

3. References

1. Streeter, V. L. and Wylie, E. B. (2010). *Fluid Transients in Systems*. Pearson.
2. Bhave, P. R. & Gupta, R. (2006). *Analysis of Water Distribution Networks*. Narosa Publishing House, New Delhi & Alpha-Science Publication.
3. Bhave, P. R. (2003). *Optimal design of water distribution networks*. Alpha Science Int'l Ltd.
4. CPHEEO (1999). *Manual on Water Supply and Treatment*. Central Public Health and Environmental Engineering Organization, Ministry Housing and Urban Affairs (Previously known as Ministry of Urban Development). New Delhi, Third Edition.
5. IS 10500:2012. Drinking Water-Specification, Second Revision.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	2
CO2	3	2	1	1	1	3
CO3	3	2	1	1	1	3
CO4	3	1	2	1	1	2
CO5	3	1	2	1	1	2

1-Low 2-Moderate 3-High

CORE ELECTIVE – 2

CECT119 Advanced Construction Materials

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Demonstrate the fundamentals of material science.
CO2	Analyze the properties of sustainable material.
CO3	Control the quality of construction.
CO4	Understand the advance concrete constituents.
CO5	Develop new binders for sustainable development.

2. Syllabus

- **MATERIAL SCIENCE** **(08 Hours)**
  Classification, standardization, codification and variety. details of micro structure of different construction materials, different effects on materials of construction.

- **PROPERTIES OF MATERIALS** **(09 Hours)**
  Environmental influences, thermal effects effect of chemicals, fire resistance, corrosion and oxidation, radiation. properties of fresh and hardened concrete. shrinkage and creep of concrete.

- **SUSTAINABLE MATERIALS** **(12 Hours)**
  Introduction, sustainability and goals, current situation, earth's natural system, carbon cycle, role of construction materials, CO2 from fossil fuel vis-à-vis cement and other construction materials. construction material and indoor air quality. energy for production, transportation and erection, estimation methodology, computation of embodied energy for building. primary energy and energy concepts.

- **ADVANCE CONCRETE** **(08 Hours)**
  High volume fly ash concrete, geo-polymer concrete and their embodied energy content against OPC concrete. aggregate resource depletion, recycled aggregate from demolition etc. role of quality control and admixtures in sustainability. durability of construction material and life cycle sustainability.

- **OTHER MATERIAL** **(08 Hours)**

Polymer materials, thermo-plastic, polymer concrete, composite, materials, ferro cement, ferro-concrete, building materials from agricultural, and industrial wastes, m-sand, glass, cladding, light weight concrete.

(Total Lectures: 45 hours. Tutorial: 15 hours)

3. References

1. Neville, A.M., and Brooks, J. J. (2012). *Concrete Technology*, Pearson Education Ltd.
2. Kubba, S. (2009). *LEED practices, certification, and accreditation handbook*. Butterworth-Heinemann.
3. Ministry of Power. (2007). *Energy Conservation Building Code*. Revised Version, Bureau of Energy Efficiency.
4. Santhakumar, A. R. (2007). *Concrete Technology*. Oxford University Press.
5. Wu, H. (Ed.). (2006). *Advanced civil infrastructure materials: Science, mechanics and applications*. Woodhead Publishing.
6. Kalliopi K. Aligizaki., (2005). *Pore Structure of Cement-Based Materials: Testing, Interpretation and Requirements*. CRC Press.
7. Newman, J. & Choo, B. S. (Eds.). (2003). *Advanced concrete technology set*. Elsevier.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	2	1	1	1
CO2	3	2	2	1	1	1
CO3	3	3	1	2	2	1
CO4	3	2	2	1	1	1
CO5	3	3	1	2	2	1

1-Low 2-Moderate 3-High

CORE ELECTIVE – 2

CECT121 Organization Management

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Develop the understanding of management concept and its relevance in organizations.
CO2	Understand human behaviour in terms of organization management and competency to implement organizational changes.
CO3	Learn concept and functions of HRM, and integrated perspective on the role of HRM in modern business.
CO4	Be able to connect various issues of IR with management and its implications; Learn Employee Discipline, Grievance procedures and various aspects of Industrial conflicts.
CO5	Understand legislative matters related to Organizational Health and Safety, compensation and salary administration.

2. Syllabus

- **PRINCIPLES OF MANAGEMENT** **(06 Hours)**

  Introduction to the field of management, development of management thoughts, characteristics and scope of management, roles and skills of managers.

- **ORGANIZATION AND HRM** **(12 Hours)**

  Concept of organization, span of control, organization structure, human resource management, recruitment, selection, placement, training and development, performance appraisal and management, change management.

- **ORGANIZATION BEHAVIOUR** **(10 Hours)**

  Individual psychology, personality, attitude, perception, motivation, morale and productivity, group dynamics, conflict management and job stress, leadership.

- **INDUSTRIAL RELATION** **(08 Hours)**

  Introduction of IR, employee safety and health, discipline and grievance, collective bargaining, trade union, compensation management.

- **LABOUR LEGISLATION** **(09 Hours)**

  Contract Labour (R &A) Act, 1970; Inter-State Migrant labour Act, 1979; Factory Act, 1948 as applicable to construction agencies, social security and welfare legislation;

laws relating to wages, bonus and industrial disputes; Labour Welfare Funds Act, 1965 and Workmen's Compensation Act, 1923.

(Total Lectures: 45 hours)

3. References

1. Rao, V. S. P. (2020). *Human Resource Management*. Paperback.
2. Gupta, C. B. (2015). Human Resource Management. Sultan Chand & Sons.
3. Monappa, A. & Saiyadain, M. S. (1999). *Personnel Management*. 2nd Edition. Tata McGraw Hill.
4. Memoria, C. B. (1997). *Personnel Management*. 1st Edition. Himalaya Publishing Co.
5. Coulter, C. & Coulter, J. J. (1989). *The Complete Standard Handbook of Construction Personnel Management*. Prentice Hall.
6. Famularo, J.J. (1986). *Handbook of Human Resources Administration*. McGraw Hill Higher Education.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	3	3	2	3	3
CO2	3	3	3	2	2	3
CO3	2	3	3	1	3	3
CO4	2	3	3	2	3	2
CO5	1	3	2	3	3	1

1-Low 2-Moderate 3-High

CORE ELECTIVE – 2

CECT123 Plumbing Engineering

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Understand the importance of plumbing in building services and terminologies related to plumbing safety.
CO2	Identify and select plumbing tools, pipe materials and fittings and their suitability for a given work.
CO3	Design plumbing services and learn emergency response plan in depth.
CO4	Analyze risks associated during plumbing activities.
CO5	Study building water distribution systems in depth

2. Syllabus

- **INTRODUCTION TO PLUMBING AND PLUMBING SAFETY (07 Hours)**
  Plumbing profession, history of plumbing, terminologies used in plumbing, phases of plumbing projects, water conserving techniques in plumbing, defects in plumbing – causes and remedies, plumbing safety, terms associated with plumbing safety, ppe, respiratory protection, hazard communication, work zone safety, safety practices – working areas and surfaces.

- **PLUMBING TOOLS, TOOL SAFETY AND WORK ENVIROMENT (07 Hours)**
  Terminologies, measuring and layout tools, leveling tools, tooth-edged cutting tools, smooth-edged cutting tools, drilling and boring tools, pipe threaders and soldering tools, assembly and holding tools, basic tool safety, trenching and excavation safety, lockout/tagout rule, safe practices for working in confined spaces, emergency response.

- **PLUMBING REGULATIONS, MATH, DRAWINGS AND COSTING (07 Hours)**
  General regulations, introduction to plumbing math, measuring pipe, construction drawings and its components, plumbing drawing and its types, plumbing costing.

- **PIPE MATERIALS AND FITTINGS (07 Hours)**
  Types of pipes and fittings, process involving cutting, connecting, testing, creating joints, suitability of different materials, quality tests.

- **FIXTURES AND FAUCETS AND DRAIN, WASTE AND VENT SYSTEMS**

(DWV) **(06 Hours)**

Introduction, terminologies, materials used to make fixtures, types of fixtures, faucets, major components of DWV systems, traps and inceptors, DWV fittings, septic tanks connections, waste treatment and health issues.

- **WATER SUPPLY AND DISTRIBUTION SYSTEMS** **(06 Hours)**

  Sources, treatment, distribution, backflow preventers and valves, building water distribution systems, various government approvals, potable water storage tanks, water pressure, pressure regulators, pressure relief valves, vacuum relief valves.

- **SERVICES** **(05 Hours)**

  Water heaters, solar power, health care facilities and medical gases pipeline systems, firestop protection – installations and inspection, fuel piping – gas piping, installation, pressure testing and inspection.

(Total Lectures: 45 hours)

3. References

1. Uniform Illustrated Plumbing Code, India (2017). Fourth Edition, IAPMO Plumbing Codes and Standards.
2. Deolalikar, S. G. (2015). *Plumbing Design and Practice*. Tata McGraw-Hill Publishers.
3. Mohan, C. R. & Anand, V. (2003). *Design and Practical Handbook on Plumbing*. Standard Publisher Distributors.
4. Harris, C. M. (1998). *Practical plumbing engineering*. McGraw-Hill Inc.,US

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	3	2	2	3
CO2	3	1	2	2	3	2
CO3	3	1	3	3	3	3
CO4	3	1	3	2	3	3
CO5	3	2	2	3	3	2

1-Low 2-Moderate 3-High

CORE ELECTIVE – 2

CECT125 Demolition of Structures

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Gain knowledge of the disposal and treatment of construction and demolition wastes.
CO2	Evaluate plan for suitable storage, collection, transfer and transfer strategies for C&D waste management.
CO3	Study in detail various environmental legislations for safe disposal of C&D wastes.
CO4	Formulate 4Rs approach for processing and recovery of C&D waste.
CO5	Understand various modern demolition methods and hazards.

2. Syllabus

- **INTRODUCTION TO C&D WASTE (07 Hours)**

  Solid waste-its classification, hazardous waste-overview, construction and demolition waste, need for disposable management, composition of C&D waste, areas of application of C&D waste, duties of waste generator, service providers and their contractors, local authority, state pollution control board, state government, central pollution control board, BIS and IRC.

- **C&D WASTE MANAGEMENT (08 Hours)**

  National and international practices, methods for managing C&D waste: on-site management, processing and recovery at a central recycling facility, land disposal, C&D waste recycling approaches: the current scenario and challenges to C&D waste recycling; hazardous materials in demolition waste; C&D waste management rules, 2016, procedures for determining potential for beneficial use.

- **LEGISLATIONS (08 Hours)**

  Environmental Legislation; characterization and site assessment; waste minimization and resource recovery; storage and transportation of C&D Waste; initiatives in promoting C & D waste products by GoI; demolition disputes and legislation.

- **TREATMENT OF C&D WASTE (08 Hours)**

  Collection and transportation of C&D waste, sorting of C&D waste, processing and treatment of C&D Waste, 4R concepts, hazard in processing and treatment; physical, chemical, thermal and biological processes; C&D waste disposal.

- **DISPOSAL OF C&D WASTE** **(07 Hours)**
  Landfill disposal and land storage, challenges and issues in C&D waste disposal; groundwater contamination: containment, remedial alternatives.

- **DEMOLITION METHODS** **(07 Hours)**
  Dismantling, demolition and deconstruction, methods of demolition – conventional demolition methods, modern demolition methods, special demolition methods, implosion; phases of demolition, demolition planning, demolition cost estimation, accidents and hazards in demolition works, challenges and issues in demolition, provisions in codes of practices.

(Total Lectures: 45 hours)

3. References

1. Construction and Demolition Waste Management Rules. 2016. MoEF & CC.
2. BSI (British Standards Institution). (2011). Code of Practice for Full and Partial Demolition, BS 6187, London, UK.
3. Building Department Hong Kong. (2004). Code of Practice for Demolition, Hong Kong.
4. BIS (Bureau of Indian Standards). (2002). Demolition of Building – Code of Safety (second revision), BIS 4130, New Delhi, India.
5. Lewandowski, G. A., & DeFilippi, L. J. (1997). *Biological Treatment of Hazardous Wastes*. John Wiley and Sons.
6. Kuhre, W. L. (1995). *Practical Management of Chemicals and Hazardous Wastes: An Environmental and Safety Professional's Guide*. Prentice Hall.
7. Haas, C. N., & Vamos, R. J. (1995). *Hazardous and industrial waste treatment*. Prentice Hall.
8. Loehr, R. C., Martin, E. J., & Johnson, J. H. (1987). Land disposal of hazardous wastes. In *Hazardous Waste Management Engineering* (pp. 365-439). Van Nostrand Reinhold Company.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	3	3	3	3
CO2	3	1	3	3	2	2
CO3	3	1	2	3	2	2
CO4	3	1	3	2	3	2
CO5	3	1	3	3	3	3

1-Low 2-Moderate 3-High

CORE ELECTIVE – 2

CETP101 Research Analytical Method

L	T	P	C
3	1	2	5

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Perform statistical analysis of the sample data collected using different sampling techniques towards insightful inferences.
CO2	Analyze different continuous and discrete probability distributions.
CO3	Develop correlations by analyzing univariate and multivariate data.
CO4	Apply hypothesis testing techniques using different sampling distributions/tests.
CO5	Solve the real-world problem with appropriate optimization tool.

2. Syllabus

- **SOCIAL RESEARCH FORMULATION** **(09 Hours)**

  Design of research - scaling techniques - sampling design - design of questionnaire - data collection and statistical processing, variables, types of variables, scaling of variables, coding of variables in software tools.

- **STATISTICS AND PROBABILITY CONCEPTS** **(09 Hours)**

  Various probability distributions and their applications - parameter estimation - hypothesis testing - random variables - method of maximum likelihood - hypothesis testing to compare multiple population - statistical quality control.

- **HYPOTHESIS TESTING** **(09 Hours)**

  Hypothesis testing, types of error in hypothesis, confidence interval, significance tests for comparing variances and means, tests with small and large samples, two-tail and one-tail student's t-test, analysis of variance (ANOVA), non-parametric tests (Chi-square test and Kolmogorov–Smirnov test), central limit theorem, practice with transportation data.

- **REGRESSION ANALYSIS** **(09 Hours)**

  Simple linear regression, residuals and variances, Assumptions, multiple linear regression, two stage regression, forward, backward and step-wise regression, residual analysis, correlation analysis, type of correlations, coefficient of correlation, Karl-Pearson's coefficient, multivariate data analysis, factor analysis, applications in transportation engineering, goodness-of-fit tests and curve fitting.

- **OPTIMIZATION TECHNIQUES** **(09 Hours)**
  Linear programming - simplex method - transportation model - concepts of non– linear programming - decision theories – rules - decision under uncertainty, applications in transportation engineering.

(Total Lectures: 45 hours)

3. References

1. Washington, S., Karlaftis, M. G., Mannering, F., & Anastasopoulos, P. (2020). *Statistical and econometric methods for transportation data analysis*. Chapman and Hall/CRC.
2. Sharma, J. K. (2010). *Quantitative Methods: Theory and applications*. MacMillan.
3. Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.
4. Bhandarkar, P. L., Wilkinson, T. S., & Laldas, D. K. (2000). Methodology & Techniques of Social Research Himalaya Publishing House.
5. Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1998). *Multivariate data analysis prentice hall*. Upper Saddle River, NJ, 730.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	3
CO2	3	2	3	2	2	2
CO3	3	3	3	3	3	3
CO4	3	3	3	3	2	3
CO5	3	2	3	3	3	3

1-Low 2-Moderate 3-High

CETP116 Airport Infrastructure Planning and Design

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Do the planning of orientation of airport elements.
CO2	Analysing the requirement of airport layout with respect to international regulation.
CO3	Design Airport Pavement, Taxiway, and Apron.
CO4	Understand visual aid required for safe landing and takeoff operation from passenger and cargo terminal.
CO5	Summarise the concept of the terminal service facility.

2. Syllabus

- **AIRPORT PLANNING** **(05 Hours)**

  Airport planning: commercial service aviation, air cargo, and general aviation; civil aviation airports; major acts and policies of the Ministry of Civil Aviation in India

  Aviation organizations and functions: Federal Aviation Administration, International Civil Aviation Organization, Directorate General of Civil Aviation, Airports Authority of India, Airport planning studies: airport system plan, airport site selection, airport master plan, airport project plan; continuous planning process.

- **AIRCRAFT CHARACTERISTICS** **(06 Hours)**

  Landing gear configurations, aircraft weight, and engine types, Atmospheric conditions affecting aircraft performance: air pressure, temperature, wind speed, and direction.

  Aircraft performance characteristics: speed, payload, range, runway performance, declared distances, wingtip vortices.

- **AIR TRAFFIC MANAGEMENT** **(06 Hours)**

  Air traffic separation rules: vertical separation, flight altitudes, longitudinal separation, and lateral separation, Navigational aids: ground-based systems, satellite-based systems.

- **GEOMETRIC DESIGN OF THE AIRFIELD** **(10 Hours)**

  Airport classification: utility airports, transport airports. Runways: runway configurations, runway orientation, the wind rose, estimating runway length, sight distance, and longitudinal profile, transverse gradient, airfield separation requirements, obstacle clearance requirements. Taxiways and taxi lanes: widths and slopes, taxiway and taxi lane separation requirements, sight distance and longitudinal profile, exit taxiway geometry, location of exit taxiways, design of taxiway curves and intersections, and end-around taxiways.

- **STRUCTURAL DESIGN OF AIRPORT PAVEMENTS (06 Hours)**
  Soil investigation and evaluation: CBR, plate bearing test, Young's modulus, the effect of frost on soil strength, subgrade stabilization. FAA pavement design methods: equivalent aircraft method, cumulative damage failure method. Design of flexible pavements: CBR method, layered elastic design. Design of rigid pavements: Westergaard's analysis, finite element theory, joints and joint spacing, continuously reinforced concrete pavements.

- **AIRPORT LIGHTING, MARKING AND SIGNAGE (06 Hours)**
  Requirements of visual aids, approach lighting system configurations, visual approach slope aids, threshold lighting. Runway lighting, taxiway lighting, Runway and taxiway marking, airfield signage.

- **PLANNING AND DESIGN OF THE TERMINAL AREA (06 Hours)**
  Passenger terminal system and its components. Design considerations: terminal demand parameters, facility classification, level of service criteria. Terminal planning process: overall space requirements, concept development, horizontal distribution concepts, vertical distribution concepts. Apron gate system: number of gates, ramp charts, gate size, aircraft parking type, apron layout, apron circulation, passenger conveyance to aircraft, apron utility requirements.

(Total Lectures: 45 hours)

3. References

1. Khanna, S. K., Arora, M. G., & Jain, S. S. (2012). *Airport planning and Design*. Sixth Edition, Nem Chand and Bros.
2. Ashford, N. J., Mumayiz, S., & Wright, P. H. (2011). *Airport engineering: planning, design, and development of 21st century airports*. John Wiley & Sons.
3. Young, S. B., & Wells, A. T. (2011). *Airport Planning and Management*. Sixth Edition,

McGraw-Hill, New York, USA.
4. Kazda, A., & Caves, R. E. (2007). *Airport Design and Operation, Second Edition, Elsevier*, Oxford, U.K.
5. Neufville, R. D., & Odoni, A. (2003). *Airport Systems: Planning, Design, and Management*. McGraw-Hill, New York, USA.
6. Horonjeff, R., McKelvey, F. X., Sproule, W. J., & Young, S. B. (1962). *Planning and design of airports* (Vol. 4). New York: McGraw-Hill.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	3	2	1	3
CO2	3	2	2	1	2	3
CO3	3	2	3	1	2	2
CO4	2	1	2	3	3	2
CO5	1	2	2	1	1	2

1-Low 2-Moderate 3-High

CORE ELECTIVE – 2

CETP119 Waterways Infrastructure Planning and Design

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Define the importance of Water Transportation and its types.
CO2	Identify the need for Harbour and Port Planning.
CO3	Design of Harbour Infrastructure.
CO4	Understanding docks and repair facilities.
CO5	Evaluate the environmental impact of the Seaport Project and economic evaluation.

2. Syllabus

- **INTRODUCTION TO WATER TRANSPORTATION (06 Hours)**

  History, scope, merits, developments of water transportation in india, inland waterways, river, canal, inland water transportation, harbor, port, dock, development of ports and harbors, classification, harbor site selection, harbor dimensioning.

- **HARBOUR AND PORT PLANNING (12 Hours)**

  Selection of site and planning of harbours, location of harbour, traffic estimation, master plan, ship characteristics, harbour design, turning basin, harbour entrances, site investigations – hydrographic survey, topographic survey, soil investigations, current observations, tidal observations.

  Characteristics of good seaport and principles of seaport planning, size of the seaport, site selection criteria and layout of the seaport, dry ports, bulk cargo, transhipment ports, port of call, surveys to be carried out for seaport planning, regional and intercontinental transportation development, forecasting cargo and passenger demand, regional connectivity, cargo handling capacity of the port.

- **HARBOUR INFRASTRUCTURE (09 Hours)**

  Ship characteristics, design of harbor entrance, design and construction of breakwaters, berthing structures - jetties, fenders, piers, wharves, dolphins, trestle, moles, navigational aids, requirements of signals, fixed navigation structures, the necessity of navigational aids, lighthouses, beacon lights, floating navigational aids, lightships, buoys, radar.

- **DOCKS AND REPAIR FACILITIES** **(06 Hours)**
  Harbor docks, use of wet docks, design of wet docks, repair docks, lift docks, dry docks, keel and bilge blocking, construction of dry docks, gates for dry docks, pumping plant, floating docks, slipways, locks, size of the lock, lock gates, types of gates.

- **DREDGING AND COASTAL PROTECTION** **(06 Hours)**
  Classification, types of dredgers, choice of dredger, uses of dredged materials, coastal erosion and protection, sea wall, revetment, bulkhead, coastal zone, and beach profile.

- **INLAND NAVIGATION** **(03 Hours)**
  Inland waterways, Inland water transportation in India, classification of waterways, the economics of inland waterways transportation, and national waterways.

- **IMPACT ANALYSIS** **(03 Hours)**
  An economic evaluation the of port project and environmental impacts of port activities.

(Total Lectures: 45 hours)

3. References

1. Khanna, S. K., Arora, M. G., & Jain, S. S. (2012). *Airport planning and Design*, Sixth Edition, Nem Chand and Bros, Roorkee, India.
2. Young, S. B., and Wells, A. T. (2011). *Airport Planning and Management*, Sixth Edition, McGraw-Hill, New York, USA.
3. Ashford, N. J., Mumayiz, S. A., & Wright, P. H. (2011). *Airport Engineering: Planning, Design, and Development of 21st Century Airports*. Fourth Edition. John Wiley and Sons, New Jersey, USA.
4. Horonjeff, R., McKelvey, F. X., Sproule, W. J., and Young, S. B. (2010). *Planning and Design of Airports*. Fifth Edition, McGraw-Hill, New York, USA.
5. Kazda, A., and Caves, R. E. (2007). *Airport Design and Operation*. Second Edition, Elsevier, Oxford, U.K..
6. Kumar, V., and Chandra, S. (1999). *Transportation Planning and Design*. Galgotia Publications Pvt. Ltd., New Delhi, India.
7. Seetharaman S. (1999). *Dock and Harbour Engineering*. Umesh Publications, New Delhi, India.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	3	3	2	2	1
CO2	3	2	2	3	2	1
CO3	3	3	3	2	3	1
CO4	3	2	3	2	2	1
CO5	2	2	2	2	2	1

1-Low 2-Moderate 3-High

CECT107 Construction Management Lab

L	T	P	C
0	0	4	2

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Study various construction management software available in industry.
CO2	Learn in depth about planning and scheduling using software.
CO3	Understand the working of MS Project and Primavera software in detail.
CO4	Prepare entire project schedule of any construction project in software.
CO5	Explore network analysis, critical path, monitoring, control, and project delays.

2. Syllabus

- **INTRODUCTION**

  Introduction to construction project models - analytical and numerical. Application of software for project planning, scheduling and control.

- **PLANNING AND SCHEDULING**

  Programming exercises for estimation, exploring user interface, working with MS Project and Primavera elements, network planning and control, creating a new OBS, EPS, WBS; adding activities; creating relationships; creating and assigning calendars; assigning roles, resources and expenses; activity and resource codes baselines, updating;

- **CONTROLLING AND UPDATING**

  Earned value analysis; S-curve and reporting project performance; Risk Management in Primavera P6; other relevant functions.

3. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	2	3	2	3
CO2	3	2	3	3	2	3
CO3	3	2	3	3	2	3
CO4	2	3	3	3	2	3
CO5	2	2	3	3	2	2

1-Low 2-Moderate 3-High

Semester II

CECT102 Construction Contract and Law

L	T	P	C
3	1	0	4

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Attain knowledge about contracts, types of contracts, contract documents and roles and functions of parties involved in a contract.
CO2	Understand the legal meaning of contract and implications.
CO3	Learn the common methods of dispute resolution in Indian scenario and understand difference between Alternative Dispute Resolution Methods and Litigation
CO4	Obtain basic understanding of typical construction and contract laws and its application in dispute resolution pertaining to construction contracts.
CO5	Be aware of common and regulatory laws to manage a construction project.

2. Syllabus

- **CONSTRUCTION CONTRACTS (12 Hours)**

  Concept of contract, types of contracts, joint venture, merging, acquisition, features and suitability, design of contract documents, international contract document, standard contract document, concession agreements, law of torts, Indian contract act 1872, Introduction to various standard forms of contract such as FIDIC, JCT and NEC.

- **CONTRACTS CLAUSES AND TERMS AND CONDITIONS (12 Hours)**

  Potential contractual problems, importance of clauses and terms and conditions of contract, rules of interpretation of contract clauses.

- **CONSTRUCTION CLAIMS, DISPUTES AND ALTERNATIVE DISPUTE RESOLUTION (10 Hours)**

  Sources of claims and disputes, construction claims procedure, methods of dispute resolution, alternative dispute resolution method, comparison of actions and laws, agreements, subject matter, violations, Arbitration and Conciliation act 1996 and recent amendments in 2015, Delay analysis, case studies, professional ethics, duties and responsibilities of parties.

- **INTERNATIONAL CONSTRUCTION CONTRACTS (11 Hours)**

  Type of contracts, surety bonds, time provisions, safety clause, insurance, employer's liability policy, builder's risk, foreign corrupt practice act, rate of inflation, use of local labor, differences in ethic, languages and culture.

(Total Lectures: 45 hours. Tutorial: 15 hours)

3. References

1. Patil, B. S., & Woolhouse, S. P. (2019). *BS Patil's building and engineering contracts*. CRC Press.
2. Bhatt, V. and Vyas, P. (2015). Laws for Engineers (Contract, Arbitration, Evidence, Limitations). Second Edition, Procare.
3. Hinze J.W. (2013.) *Construction Contracts*. 3rd Edition. McGraw Hill.
4. Bockrath, J. T. (2013). *Contracts and the legal environment for engineers and architects.* McGraw Hill
5. Fenn, P. (2012). *Commercial Conflict Management and Dispute Resolution*. Spon Press.
6. Ndekugri, I., & Rycroft, M. (2009). *The JCT Standard Building Contract: Law and Administration*. Elsevier.
7. Murdoch, J., & Hughes, W. (2002). *Construction contracts: law and management*. Routledge.
8. Atkinson, D. (2007). *Causation in Construction Law – Principles and Methods of Analysis*. Danial Atkinson Limited.
9. Ramaswamy, B. S. (2005). *Contracts and their Management*. Lexis Nexis Butterworths.
10. Murdoch, J and Hughes, W (2002). *Construction Contracts*. Spon Press.
11. Arbitration Act (1996) (with amendment 2015)

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	1
CO2	2	3	2	2	2	1
CO3	2	3	2	2	3	1
CO4	3	3	3	3	3	3
CO5	3	2	2	3	3	3

1-Low 2-Moderate 3-High

CECT104 Construction Quality and Safety

L	T	P	C
3	1	0	4

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain the importance of quality and quality management methods in construction.
CO2	Develop quality assurance plan to meet required international and national quality standards.
CO3	Understand importance of various aspects of safety during execution of construction activities.
CO4	Learn the application of the principles and theories of safety to construction projects.
CO5	Identify the causes, investigations and prevention of accidents in construction job sites.

2. Syllabus

- **CONSTRUCTION ORGANIZATION** **(08 Hours)**

  Types of organization, inspection, control and enforcement, quality management systems and method, responsibilities and authorities in quality assurance and quality control; architects, engineers, contractors, and consultants, quality circle.

- **QUALITY ASSURANCE AND CONTROL** **(08 Hours)**

  Objectives, regularity agent; owner, design, contract and construction-oriented objectives, methods/techniques and needs of QA/QC different aspects of quality, appraisals, factors influencing construction quality-critical, major failure aspects and failure mode analysis stability methods and tools, optimum design, reliability testing, reliability coefficient and reliability prediction selection of new materials.

- **TOTAL QUALITY MANAGEMENT** **(08 Hours)**

  Road Map for TQM Implementation, role of management in TQM, Quality improvement planning measurement, construction site implementation, six sigma in quality management.

- **SAFETY AND HEALTH IN CONSTRUCTION** **(06 Hours)**

  Safety and accidents in construction projects, theories of accident causation, health and illness related with construction works, cost of construction injuries, safety risk analysis and control, personal protective equipment, occupational and safety hazard assessment, legal implications, OSH Management System.

- **SAFETY PROGRAMME AND CONTRACTUAL OBLIGATIONS (07 Hours)**

  Problem areas in construction safety, elements of an effective safety programme, job site safety assessment, safety meetings, and safety incentives Safety in construction contracts, substance abuse, safety record keeping.

- **DECISION FOR SAFETY (08 Hours)**

  Safety culture, safe workers, safety and first line supervisors, safety and middle managers, top management practices, company activities and safety, safety personnel, sub contractual obligation, project coordination and safety procedures and workers compensation.

(Total Lectures: 45 hours)

3. References

1. David, L. G. (2023). *Occupational safety and health for technologists, engineers, and managers*. Prentice Hall.
2. Jha, K.N., Patel, D.A., & Singh, A. (2022). *Construction Safety Management*. Pearson Education Services, Noida.
3. Rumane, A. R. (2013). *Quality tools for managing construction projects*. CRC Press.
4. Rumane, A. R. (2011). *Quality management in construction projects*. CRC Press.
5. Rumane, A. R. (2011). *Quality management in construction projects*. CRC Press.
6. Yang, K., & El-Haik, B. S. (2009). *Design for Six Sigma*. Tata McGraw Hill.
7. Holt, A. S. J. (2005). *Principles of construction safety*. Blackwell Publishers.
8. Hinzie, J.W. (1997). *Construction safety*, Prentice Hall.
9. Levitt, R. E., & Samelson, N. M. (1993). *Construction safety management*. John wiley & sons.
10. Juran J M and Gryna, F. M. (1993). Q*uality Planning and Analysis: From Product Development through Use*. 3rd Edition, Tata McGraw Hill.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	2	3	2	3
CO2	3	2	3	2	2	2
CO3	3	2	3	3	2	1
CO4	3	2	3	3	2	1
CO5	3	3	2	3	2	1

1-Low 2-Moderate 3-High

CORE ELECTIVE – 3

CECT112 Precast and Prestress Construction

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Appraise uses of precast and prestress construction.
CO2	Explore construction techniques for precast and prestressed components.
CO3	Plan activities for precast and prestress construction.

2. Syllabus

- **PRECAST CONSTRUCTION** **(10 Hours)**

  Necessity of precast construction, advantages & disadvantages, challenges and limitations, precast concrete production, materials used in precast concrete, mixing, casting, and curing processes, moulds and formwork, types of moulds, logistics and handling, transportation methods, handling and storage of precast elements, installation techniques, quality control measures, testing and inspection, ensuring compliance with standards, safety protocols during manufacturing and installation

- **MODULAR CONSTRUCTION** **(10 Hours)**

  Modular coordination, basic module, planning and design modules, modular grid systems, national building code specification, standardization, dimensioning of products, preferred dimensions and sizes, tolerances and deviations layout and processes.

- **PREFABRICATES** **(7 Hours)**

  Classification, foundation, columns, beams, roof and floor panels, wall panels, clay units, box prefabricates erection and assembly.

- **PRESTRESSED CONSTRUCTION TECHNIQUES** **(10 Hours)**

  Types of prestressing, material used, prestressing equipment, methodology adopted for horizontal and vertical transportation, benefits, challenges, and future trend. applications and project case studies.

- **CONSTRUCTION TECHNIQUES** **(08 Hours)**

  Large panel construction, lift slab system, glover system, jack block system, segmental construction, incremental launching, tilt-up construction, composite construction.

(Total Lectures: 45 hours)

3. References

1. Bayliss, S., & Bergin, R. (2020). *The modular housing handbook*. Routledge.
2. Elliott, K. S. (2019). *Precast concrete structures*. CRC Press.
3. Hong, W. K. (2019). *Hybrid composite precast systems: Numerical investigation to construction*. Woodhead Publishing.
4. Libby, J.R. (2012). *Modern Prestressed Concrete: Design Principles and Construction Methods*, Springer-Verlag New York Inc Publishers.
5. Bachmann, H., and Steinle, A. (2011). *Precast concrete structures*. Berlin: Ernst & Sohn.
6. Smith, R. E. (2010). *Prefab architecture: A guide to modular design and construction.* John Wiley & Sons.
7. Gerwick Jr, B. C. (1997). *Construction of prestressed concrete structures*. John Wiley & Sons.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	2	3	3	2	3
CO2	2	1	3	3	2	3
CO3	2	1	3	2	3	2

1-Low 2-Moderate 3-High

CORE ELECTIVE – 3

CECT114 Building Information Modeling (BIM)

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Understand Building Information Modelling and various BIM software systems.
CO2	Explore model-based engineering workflows in building and infrastructure lifecycles.
CO3	Achieve engineering objectives of virtual design and construction in practice.
CO4	Learn construction scheduling, quantity take-offs and run nD simulations using BIM software.
CO5	Utilize BIM for system clash detection and prevention.

2. Syllabus

- **INTRODUCTION OF BIM** **(07 Hours)**

  Introduction to BIM process and integrated project delivery, nD modelling, BIM software systems and guidelines to choosing different BIM software systems.

- **BASIC MODELLING** **(07 Hours)**

  Introduction of modelling environment and tools, modelling approaches to producing plans, 3D models, views and sections of buildings, creating an initial sample of 3D BIM model using a BIM authoring software, modelling of building including basic and vital elements, production of plans, views and 3D models, annotations and preparations of sheets for printing and publishing.

- **ADVANCE CONCEPTS** **(08 Hours)**

  Model customizations, elements and materials, creation of internal components, external elements, massing and site modelling, Elements visibility, visualization and walkthroughs, model/information exchange and merging of models.

- **nD MODELLING** **(08 Hours)**

  Introduction to aspects of nD modelling, scheduling and quantity take-offs using BIM-enabled systems and export to spreadsheets, Production of a 4D program in 4D BIM software, cost estimation, producing cost estimates in a 5D BIM software.

- **INTEROPERABILITY IN BIM** **(08 Hours)**

  Basics about interoperability, Export formats and applications, exchange of information through IFC, COBie, BIM 360 Glue, Mobile BIM.

- **ADVANCES IN BIM** **(07 Hours)**

  Clash detection, Overview of clash detection tools, use of software to detect/resolve clashes in a BIM model, project collaboration using cloud/mobile BIM systems and common data environments.

(Total Lectures: 45 hours)

3. References

1. Hardin, B., & McCool, D. (2015). *BIM and construction management: proven tools, methods, and workflows*. John Wiley & Sons.
2. Eastman, C. M. (2011). *BIM handbook: A guide to building information modeling for owners, managers, designers, engineers and contractors*. John Wiley & Sons.
3. Kymmell, W. (2008). *Building Information Modeling: Planning and Managing Construction Projects with 4D CAD and Simulations (McGraw-Hill Construction Series): Planning and Managing Construction Projects with 4D CAD and Simulations.* McGraw Hill Professional.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	2	2	2	3	3
CO2	2	1	3	2	3	3
CO3	3	2	3	3	3	3
CO4	3	1	2	3	3	3
CO5	3	1	2	3	3	3

1-Low 2-Moderate 3-High

CORE ELECTIVE – 3

CECT116 Real Estate Valuation

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Learn the concepts of microeconomics and macroeconomics and parallel economy.
CO2	Comprehend the various laws on valuation and real estate.
CO3	Understand the elements involved in property valuation.
CO4	Explore the various approaches involved in real estate valuation.
CO5	Know the principles of insurance, risk, and loss assessment.

2. Syllabus

- **PRINCIPLES OF ECONOMICS** **(06 Hours)**
  Introduction, microeconomics, factors of production and their pricing, theory of rent, capital and interest, macroeconomics, deflation, savings and investment, components of economy, concepts of gross domestic product and gross national product, capital formation, etc., parallel economy, impact on real estate market and construction industry.

- **LAWS ON VALUATION** **(04 Hours)**
  Insolvency and Bankruptcy Code, 2016; The Companies Act, 2013: Sections 192(2), 230(1), 230(2), 230(3), 231, 232, 247 and 281(1); Companies (Registered Valuers and Valuation) Rules, 2017; Securitization and Reconstruction of the Financial Assets and Enforcement of Security Interest Act, 2002 (SARFAESI Act, 2002) concerning valuation; Section 5(n) of the Banking Regulation Act, 1949 on 'secured loan or advance'.

- **LAWS RELATED TO REAL ESTATE** **(06 Hours)**
  Land Acquisition- the right to fair compensation and transparency in the land acquisition, the Rehabilitation and Resettlement Act, 2013; General building rules and regulations; Rent control laws; Right of way and Section 52: licenses under the Indian Easements Act, 1882; Salient features of the Real Estate (Regulation and Development) Act, 2016 and regulating authorities established under the Act; The Transfer of Property

Act, 1882.

- **VALUATION OF REAL ESTATE** **(09 Hours)**
  Cost, price and value; types of value; basic elements of value – marketability, utility, scarcity, and transferability; factors affecting value; real property: rights and interests in real estate, types of ownerships and types of occupancy in real estate; annuities, capitalisation and rate of capitalization, years purchase, sinking fund, redemption of capital, reversionary value; construction and use of valuation tables; urban infrastructure and its influence on value of real estate; real estate market and its characteristics, investment in real estate, factors influencing demand and supply schedule in real estate.

- **APPROACHES TO VALUE** **(16 Hours)**
  Income Approach to Value: discounted cash flow techniques, capital assets pricing model, profit method for valuation of special properties, Market Approach to Value, Hedonic model and adjustment grid model under sales comparison method, land characteristics and its effect on land values, hypothetical plotting scheme for value of large size land, residue technique and other development methods, valuation for joint venture development of property; Cost Approach to Value, Various purpose of Valuation.

- **PRINCIPLES OF INSURANCE AND LOSS ASSESSMENT** **(04 Hours)**
  Principles and legal concepts in relation to insurance of buildings, contract of insurance, insurable interests, liability to insure, duties of the insurer and the insured; types of fire policies, reinstatement value, indemnity policies and policies for other perils; value at risk, sum insured and condition of average, over and under insurance, provisions regarding inflation, depreciation, obsolescence and betterment; preparation of claim for damages due to insured perils; obligations and rights of insurer and insured.

(Total Lectures: 45 hours)

3. References

1. Savla, H (2021) Real Estate Valuation, Notion Press.
2. Shapiro, E., Mackmin, D., & Sams, G. (2019). *Modern methods of valuation*. Estates Gazette.
3. Mooya, M. M. (2016). *Real estate valuation theory*. Springer Books.

4. Blackledge, M. (2016). *Introducing property valuation*. Routledge.
5. Natarajan, K., & Nedunchezhiyan B. (2016). *Indian Real Estate Law 2016*. Notion Press.
6. Scarrett, D., & Osborn, S. (2014). *Property valuation: The five methods*. Routledge.
7. Betts, R. M., & Ely, S. J. (2007). *Basic Real Estate Appraisal*. Prentice-Hall.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	2	1	2	2	1
CO2	2	3	2	3	3	2
CO3	3	3	3	3	3	3
CO4	3	2	2	3	3	3
CO5	2	2	2	3	3	3

1-Low 2-Moderate 3-High

CORE ELECTIVE – 3

CEEN111 Environmental Legislation and Impact Assessment

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Interpret and explain the objectives and scope of EIA.
CO2	Categorize the importance of environmental attributes.
CO3	Describe the legal provisions and statutory requirement of environmental clearance.
CO4	Calculate the identification and prediction of environmental impacts of new/expansion projects.
CO5	Formulate an EIA for any given project.

2. Syllabus

- **IMPACT ASSESSMENT: TYPES AND SIGNIFICANCE (03 Hours)**
  Types of impacts, significant impacts, various impact assessments viz. health impact assessment, social impact assessment, disaster impact assessment, strategic environmental assessment.

- **EIA: INTRODUCTION & PLANNING (06 Hours)**
  Evolution of EIA; EIA at project; regional and policy levels; EIA legislative and environmental clearance procedures in India; EIA Rules-1994 and subsequent amendments, rapid and comprehensive EIA.

- **EIA: METHODOLOGIES AND STRATEGIES (14 Hours)**

  Screening, baseline data collection, environmental inventory of physical, biological and socio-economic environment attributes, terms of reference, scoping, identification of impacts, rapid and comprehensive EIA, monitoring, analysis and report preparation in EIA, impact prediction tools / techniques such as adhoc method, checklist method, development of environment management plan, post project monitoring.

- **PUBLIC PARTICIPATION (03 Hours)**
  Project affected persons, significance of public participation in EIA, methods of public consultation – Public Notice and Public Hearing, Resettlement and rehabilitation issues, Land Acquisition, Rehabilitation and Resettlement Act, 2013.

- **EIA CASE STUDIES** **(10 Hours)**

  Case studies / histories for different types of projects like metro rail project, nuclear power project, large hydro-electric power project, pharmaceutical industry, township and area development projects.

- **NATIONAL ACTS & RULES FOR ENVIRONMENTAL PROTECTION**

  (09 Hours)

  Indian environmental legislation and acts such as Water Act-1974, Air Act-1981, Wildlife Protection Act-1972, Forest Conservation Act-1980, Public Liability Insurance Act 1991, Environment Protection Act (EPA) – 1986; Various Rules under EPA-1986 such as Biomedical Waste Rules-2016, Coastal Regulation Zone-1999, Municipal Solid Waste rules, Hazardous Waste Rules-2016, Noise Regulation & Control Rules-2000, National Green Tribunal, NGT Act-2010, Case studies of landmark judgements given by NGT and various Courts.

(Total Lectures: 45 hours)

3. References

1. Dhameja S.K. (2004). *Environmental Engineering and Management*. S. K. Kataria & Sons, Delhi.
2. Canter L.W. (1996). *Environmental Impact Assessment*. Tata McGraw Hill Co, Singapore.
3. Munn R.E. (1979). *Environmental Impact Assessment*. John Wiley & Sons, Toronto,
4. Relevant MoEF&CC Notifications and CPCB Acts & Rules.
5. Weblinks – 1) https://cpcb.nic.in/index.php 2) https://moef.gov.in/en/rules-and-regulations/environment-protection/ 3) https://cpcb.nic.in/general-standards/

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	1	2	3	3	3
CO2	2	3	2	3	2	3
CO3	1	3	1	3	2	2

CO4	3	1	3	3	3	3
CO5	3	3	3	2	3	2

1-Low 2-Moderate 3-High

CORE ELECTIVE – 3

CEEN120 Applied Statistics for Engineers

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Analyze and interpret engineering data.
CO2	Use hypothesis testing for various cases.
CO3	Apply different sampling distributions to engineering data.
CO4	Develop simple linear regression and correlation.
CO5	Design statistical experiments.

2. Syllabus

- **INTRODUCTION** **(07 Hours)**

  Graphical presentation of data: dot and scatter plots – frequency distribution and histogram – box plot and time plots – numerical distribution of data: measures of central tendency – dispersion – skewness and kurtosis – measuring association – grouped data.

- **SAMPLING DISTRIBUTIONS** **(10 Hours)**

  Random variables and expectation – discrete and continuous random variables – sampling distributions – important discrete distributions – binomial – poisson and geometric distributions – normal distribution – central limit theorem.

- **PARAMETER ESTIMATION** **(06 Hours)**

  Point estimation – Confidence interval estimation.

- **TESTS OF HYPOTHESIS** **(08 Hours)**

  Tests of hypothesis on single sample and two samples – Goodness of fit – Tests based on Normal – t – Chi–square – F distributions.

- **SIMPLE LINEAR REGRESSION AND CORRELATION** **(06 Hours)**

  One way and two way classification.

- **DESIGN OF EXPERIMENTS** **(08 Hours)**

  Completely randomized single factor experiment – Analysis of variance – Randomized block design – Latin square design – 2^2 factorial design.

(Total Lectures: 45 hours)

3. References

1. Box G.E.P, Hunter J.S., & Hunter W.G. (2005). *Statistics for Experimenters*. John Wiley and Sons
2. Berthouex P.M., & Brown L.C. (2002). *Statistics for Environmental Engineers*. CRC Press.
3. Walpole R.E. Myers R.H., Myers S.L., & Ye K. (2002). *Probability and Statistics for Engineers and Scientists*. Pearson Education, New Delhi.
4. Johnson D. E. (2002). *Applied multivariate methods for data analysis*. Thomson & Duxburg Press, Singapore.
5. Freund J.E., & Miller I.R. (1994). *Probability and Statistics for Engineers*. Prentice–Hall of India.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	1	3	2	2	3
CO2	1	1	3	2	2	2
CO3	2	2	3	2	2	1
CO4	2	2	3	2	1	1
CO5	2	2	3	2	1	2

1-Low 2-Moderate 3-High

CEGT201 Ground Improvement Techniques

L	T	P	C
3	1	0	4

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Identify the mineral composition responsible for the weak soil deposits and problems associated with it.
CO2	Understand general construction procedures and inspection items for ground improvement techniques.
CO3	Analyze various index/strength properties of soil and suggest suitable ground improvement method.
CO4	Ability to design the ground improvement methods as per site requirements using various national/international codal guidelines.
CO5	Ability to prepare numerical modelling for various ground improvement techniques.

2. Syllabus

- **INTRODUCTION** **(06 Hours)**

  Ground improvement: definition, objectives of soil improvement, classification of ground improvement techniques, factors to be considered in the selection of the best soil improvement technique. weak deposits – identification – problems associated with weak deposits – Mitchel chart of applicability of treatment methods – principles – suitable methods. mechanical modification, principle of modification for various types of soils.

- **DEEP GROUND IMPROVEMENT** **(10 Hours)**

  In-situ compaction of cohesion less soil – dynamic compaction and blasting – vibro flotation – stone column – encased stone column, stone column design as per codal provisions – strengthening of sub soil by stone column installation. lime piles.

- **HYDRAULIC MODIFICATION** **(06 Hours)**

  Definition, aim, principle, techniques. gravity drain, lowering of water table, multistage well point, vacuum dewatering. discharge equations. design of dewatering system including pipe line effects of dewatering, preloading, vertical drains, sand drains. assessment of ground condition for preloading, electro kinetic dewatering.

- **GEOSYNTHETICS AND REINFORCED SOIL** **(07 Hours)**

Types of geosynthetics like geotextiles, geogrids, geonets, geocells, geo-composites, their functions, applications and manufacturing methods. Index properties and Strength properties of Geosynthetics. Historical background of reinforced soil, Principles of reinforced soil. Concept of MSE wall and Reinforced Soil slopes.

- **GROUTING** **(06 Hours)**
  Types of grouts, desirable characteristics of grout, grouting methods- permeation grouting, displacement-compaction grouting, displacement-soil fracture grouting, jet or replacement-displacement grouting. grouting pressure, grouting technology.

- **SOIL STABILIZATION** **(05 Hours)**
  Soil stabilization with admixtures like lime, flyash, cement etc, properties of chemical components, reactions and effects. Bitumen, tar or asphalt in stabilization.

- **MISCELLANEOUS METHODS** **(05 Hours)**
  Micro piles, soil nailing, ground Anchors, ground freezing and heating methods.

(Total Lectures: 45 hours)

3. References

1. Jie H. (2018). *Principles and Practice of Ground Improvemen*. Wiley India.
2. Indraratna, B., Chu, J., & Rujikiatkamjorn, C. (2015). *Ground improvement case histories: compaction, grouting and geosynthetics*. Butterworth-Heinemann. – Elsevier.
3. Hausmann M.R. (2013). *Engineering Principles of Ground Modification*. McGraw Hill Publishing Company, New York.
4. Koerner, R.M. (2012). *Designing with Geosynthetics*. Prentice Hall, New Jersey, USA, 6th edition.
5. Design guidelines from IS code, FHWA, BS, and other codal organizations

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	1	1	2	2	2
CO2	1	1	1	2	1	1
CO3	2	2	2	2	2	1
CO4	2	2	2	2	2	2
CO5	2	2	3	2	2	2

1-Low 2-Moderate 3-High

CORE ELECTIVE – 3

CETP126 Road Safety and Environment

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Analyze the present scenario about transport safety and environment with a multidisciplinary approach.
CO2	Examine factors affecting road safety engineering and crash investigation, human factors relating to crashes/accidents, crash/accident.
CO3	Predict hazard identification related to the transport safety and environment and take management measures for improving safety and environment.
CO4	Create awareness about empathetic and improving the present practices related to the Transportation Safety Audit and Environmental Impact Assessment (EIA) for transportation projects.
CO5	Evaluate effectiveness of measures for improving traffic safety and environment.

2. Syllabus

- **INTRODUCTION** **(06 Hours)**

  Transportation safety scenario in India and world, accident characteristics, distribution among different modes. need of planning for network, land use and road environment for safety, designing for safety: road link design, junctions. introduction to road safety engineering and crash investigation, human factors relating to crashes/accidents, crash/Accident.

- **ROAD SAFETY DIAGNOSIS** **(06 Hours)**

  Investigation and crash problem diagnosing, crash problems into solutions and crash, investigation reporting, crash/accident, costing, economic appraisal. safety at construction site: safety provisions for workers at construction site, construction zone markings, signs.

- **ROAD SAFETY AUDIT** **(10 Hours)**

  Road Safety Auditing: An Introduction, Concept and need of Road Safety Audit (RSA). Procedures in RSA, design standards, audit tasks, stages of road safety audit, Road Safety Audit Types, key legal aspects, process, audit team and requirements, Checklist, how to use Checklists Road Safety inspection.

- **TRANSPORT AND ENVIRONMENT ISSUES** **(08 Hours)**

  Introduction to transport and the environment: context, mechanisms and sustainability; air pollution: mechanisms, technology solutions, modelling and social costs; traffic noise: units, sources, and impacts climate change: transport contribution, potential impacts, regulatory framework and policies.

- **MEASUREMENT AND MODELLING** **(08 Hours)**

  Environmental planning and assessment practices, Measurement of environmental impacts of transport: Emissions, air quality and noise, Modelling of environmental impacts of transport: Emissions, air quality and noise, Land use transport relationships.

- **IMPACT ASSESSMENT** **(07 Hours)**

  Environmental impact assessment for transportation projects: basic concepts, objectives, transportation related environmental impacts; vehicular impacts; safety and capacity impacts; roadway impacts, construction impacts, environmental impact assessment, environmental impact statement, environment audit, typical case studies.

(Total Lectures: 45 hours)

3. References

1. IRC SP:88. (2019). Manual on Road Safety Audit.
2. Robinson, R., & Thagesen, B. (2018). *Road engineering for development*. CRC Press.
3. Tiwari, G., & Mohan, D. (Eds.). (2018). *Transport planning and traffic safety: making cities, roads, and vehicles safer*. CRC Press.
4. Elvik, R., Høye, A., Vaa, T., & Sørensen, M. (2009). *The handbook of road safety measures*. Emerald Group Publishing Limited.
5. Evans, L. (2004). Traffic safety. science serving society. *Bloomfield Hills, MI*, *179*.
6. Baker, K. S. (2001). *Traffic collision investigation*. Evanston, IL, USA: Northwestern University Center for Public Safety.
7. Hauer, E. (1997). *Observational before/after studies in road safety. Estimating the effect of highway and traffic engineering measures on road safety*.
8. Institute of Transportation Engineers. (1993). *The Traffic Safety Toolbox: A Primer on Traffic Safety*. Institute of Transportation Engineers.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	0	2	2	2	3
CO2	3	2	3	1	2	2
CO3	2	2	3	2	2	2
CO4	1	2	2	2	2	3
CO5	3	0	3	2	2	2

1-Low 2-Moderate 3-High

CORE ELECTIVE – 3

CEUP102 Urban Infrastructure Planning

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Understand Urban Infrastructure fundamentals with practical application.
CO2	Review different norms and guidelines of municipal infrastructure.
CO3	Adopt the most suitable management techniques for the better maintenance of infrastructure in future growth.
CO4	Identify different shortcomings and challenges in the current practices.
CO5	Explore modern techniques and technology in place of conventional methods.

2. Syllabus

- **URBAN INFRASTRUCTURE PLANNING** **(05 Hours)**

  Data required for provision and planning of urban infrastructure, types, significance, impact on urban form, norms, and financial aspects, public private, SPV and PPP models in infrastructure provisions, infrastructure policy.

- **NETWORKS AND SERVICES SYSTEMS** **(06 Hours)**

  Urban services overview, classification and significance, concepts and theories for design and operation, components, interrelationship, requirements of appropriate technology, cost recovery, gap analysis.

- **WATER SUPPLY NETWORK** **(06 Hours)**

  City and household network scenario, norms, national water policy, water rights: excess and underutilization of water, role of community in water provision, water harvesting, privatization of water supply and its implications.

- **SEWERAGE NETWORK** **(06 Hours)**

  City and household network scenario, norms. sewerage drainage, refuse collection, storage, recycling and disposal, minimum basic needs, formulation of objectives, norms and standards both for space allocation and quality control, storm water network.

- **SANITATION AND SOLID WASTE MANAGEMENT** **(06 Hours)**

  Types, generation, collection system, transfer station location, segregation, transportation, disposal, site selection, effect of population density, impact of urban land use, bio-medical waste and disposal, policies and programs in the provision of sanitation at various level, low-cost sanitation, city sanitation plan and state sanitation strategies, cost recovery in solid waste.

- **ELECTRICITY AND COMMUNICATION NETWORK (06 Hours)**
  Planning for electrification, current scenario, services and space standards of transformers space standards for electricity networks, space station location, street lighting requirements, communication network requirement.

- **SOCIAL INFRASTRUCTURE (10 Hours)**
  Health and education hierarchy, norms and location. energy distribution, fire protection: requirements, norms and standards, planning provision, milk distribution system, recreation and open space planning in social infrastructure.

(Total Lectures: 45 hours)

3. References

1. Yigitcanlar, T. (Ed.). (2010). *Sustainable urban and regional infrastructure development: Technologies, applications and management: Technologies, applications and management*. IGI Global.
2. National Institute of Urban Affairs (2005). Status of water supply, sanitation, and solid waste management in the urban area.
3. CPHEEO (2013). CPHEEO Manual on Sewerage and Sewage Treatment Systems.
4. CPHEEO (2016). CPHEEO Manual on Municipal Solid Waste Management.
5. CPHEEO (2019). CPHEEO Manual on Storm Water Drainage Systems.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	0	0	0	2	2	2
CO2	1	1	2	3	2	2
CO3	3	1	3	3	2	1
CO4	1	2	1	3	3	2
CO5	3	3	3	2	2	2

1-Low 2-Moderate 3-High

CORE ELECTIVE – 4

CECT118 Disaster Risk and Resilience

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Review the concept of disaster and disaster management.
CO2	Recognize institutions and organization setup.
CO3	Identify housing design and planning at pre and post disaster level.
CO4	Integrate disaster management in development plan.
CO5	Apply soft skill for disaster mitigation strategies.

2. Syllabus

- **DISASTER** **(10 Hours)**

  Meaning, factors and significance, characteristic, dimensions, causes and effects of natural hazards disaster and development, global disaster trends, emerging risks of disasters, climate change and urban disasters, resilience.

- **DISASTER RISK REDUCTION AND MANAGEMENT** **(11 Hours)**

  Regional and seasonal, scope and objectives of disaster mitigation, preparedness and response. prerequisite for preparedness planning, action plans and procedure, models and checklists. disaster response planning in tsunami and natural hazards or natural disasters, roles and responsibilities of various agencies, emergency operation support and management. role of urban planner.

- **DISASTER MANAGEMENT AND RESILIENT SYSTEM** **(12 Hours)**

  Disaster management cycle, need assessment and resilient system, risk management, zonation and micro zonation, prevention and mitigation of disasters, early warning system; preparedness, capacity development during the different phases of disaster, technologies for disaster management.

- **AWARENESS DURING DISASTER** **(12 Hours)**

  Evacuation, disaster communication, search and rescue, emergency operation center, incident command system, relief and rehabilitation, post-disaster, damage and needs assessment, restoration of critical infrastructure, early recovery, reconstruction and redevelopment, policy implementation and case studies.

(Total Lectures: 45 hours)

3. References

1. Sharma, V. (2013). *Disaster Management*. National Center for Disaster Management. Scientific International private limited.
2. Federica, R. (2012). *A Workbook on Planning for Urban Resilience in the Face of Disaster.* World Bank Publication.
3. Debora, M. (2011). *Urban Planning and Disaster Risk Management.* Lambert Academic.
4. Gupta, H. K. (2003). *Disaster management*. Universities Press.
5. Collins, L. R. (2000). *Disaster management and preparedness*. CRC Press.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	1	1	3	1	3
CO2	1	0	0	3	1	2
CO3	2	1	2	3	1	2
CO4	3	3	3	2	1	3
CO5	3	2	3	1	1	2

1-Low 2-Moderate 3-High

CORE ELECTIVE – 4

CECT120 Maintenance and Rehabilitation

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Understand the concept of maintenance of the structures.
CO2	Inspect and evaluate the damaged structure.
CO3	Analyze the structures through serviceability and durability point of view.
CO4	Compare the different materials used for the repairing and its proper application.
CO5	Evaluate the techniques and methodology for the repairing of the structures.

2. Syllabus

- **MAINTENANCE AND REPAIR STRATEGIES (08 Hours)**

  Maintenance, repair and rehabilitation, facets of maintenance, importance of maintenance, various aspects of inspection, assessment procedure for evaluating a damaged structure, causes of deterioration.

- **SERVICEABILITY AND DURABILITY OF CONCRETE (10 Hours)**

  Quality assurance for concrete, strength, durability and thermal properties of concrete, cracks, different types, causes, effects due to climate, temperature, sustained elevated temperature, corrosion, effects of cover thickness and cracking.

- **MATERIALS FOR REPAIR (08 Hours)**

  Special concretes and mortar, concrete chemicals, special elements for accelerated strength gain, Expansive cement, polymer concrete, Sulphur infiltrated concrete, Ferro cement, Fibre reinforced concrete.

- **TECHNIQUES FOR REPAIR AND PROTECTION METHODS (09 Hours)**

  Rust eliminators and polymers coating for rebars during repair foamed concrete, mortar and dry pack, vacuum concrete, gunite and shotcrete epoxy injection, mortar repair for cracks, shoring and underpinning. methods of corrosion protection, corrosion inhibitors, corrosion resistant steels, coatings and cathodic protection. engineered demolition techniques for dilapidated structures – case studies.

- **REPAIR, REHABILITATION AND RETROFITTING OF STRUCTURES**

(08 Hours)

Repairs to overcome low member strength. deflection, cracking, chemical disruption, weathering corrosion, wear, fire, leakage and marine exposure.

(Total Lectures: 45 hours)

3. References

1. Allen R. T., Edwards, S. C. and Shaw, J. D. N., (2013). *Repair of Concrete Structures*,. 2nd Edition, Springer.
2. Gupta, B. L. (2009). *Maintenance and Repair of Civil Structures*. Standard Publication, Delhi.
3. Raikar, R. N. (2002). *Learning from Failures: Deficiencies in Design, Construction, and Service*. R & D Centre, Structwel Designers & Consultants.
4. Campbell-Allen, D., & Roper, H. (1991). *Concrete structures: materials, maintenance and repair*.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	2
CO2	3	2	3	3	3	2
CO3	2	1	3	2	3	2
CO4	3	2	3	3	3	2
CO5	3	3	3	3	3	2

1-Low 2-Moderate 3-High

CORE ELECTIVE – 4

CECT122 Heritage Conservation and Management

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Understand the forms of heritage structures and materials.
CO2	Be aware of roles and responsibilities of a conservation engineer and be able to implement and manage the heritage conservation project.
CO3	Explore the advanced methods of inspection and condition assessment of heritage buildings.
CO4	Study the properties of historic building materials.
CO5	Derive characteristics of heritage conservation projects and diagnose heritage structures for conservation.

2. Syllabus

- **IMPORTANCE OF HERITAGE CONSERVATION (07 Hours)**

  Definition of heritage, classification of heritage, problems and causes of defects in heritage structures, history of conservation, heritage conservation act, UNESCO strategy and efforts towards heritage conservation, national and international bodies and charters for heritage conservation and management.

- **CONSERVATION ENGINEERING (07 Hours)**

  Basics of conservation, introduction to interventions, degree of intervention, prevention of deterioration, restoration, rehabilitation, reproduction, reconstruction, translocation, conservation engineering as arts and science, technologies for intervention, role of conservation engineer.

- **HISTORIC STRUCTURAL FORMS (08 Hours)**

  Forms of historical structure and monuments, built forms in ancient times, built forms in old times, built forms in modern times, structural elements of heritage, historic roof systems, historic brick and stone work, behaviour of heritage buildings, finite element method.

- **HISTORICAL MATERIALS (08 Hours)**

  Martials in historic times, lime, stone, wood, timber, historic mortars, historic masonry, types of material problem and failures, recreation of historic materials, simulation of historic materials.

- **INSPECTION AND DIAGNOSIS** **(07 Hours)**
  Methods of inspection and condition assessment, reporting and records, diagnosis methods, sensors, radars, sonic tomography, rebound tests, magnetometry analysis, visual methods, image processing, artificial intelligence.

- **CONSERVATION MANAGEMENT** **(08 Hours)**
  Characteristics of heritage conservation project, planning and organization of conservation project, WBS of conservation project, scheduling and activities of conservation project, digital technologies for conservation planning, analysis and simulations.

(Total Lectures: 45 hours)

3. References

1. Toniolo, L., Boriani, M., & Guidi, G. (Eds.). (2015). *Built heritage: monitoring conservation management.* Cham: Springer International Publishing.
2. Pickard, R. (2001). *Policy and law in heritage conservation.* (Vol. 1). Taylor and Francis.
3. Mathews, M. S. (1998). *Conservation Engineering*. Universidad Karlsruhe.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	2	3	3	2
CO2	3	3	2	3	2	2
CO3	3	1	3	2	2	2
CO4	3	3	2	3	3	1
CO5	3	1	3	3	3	2

1-Low 2-Moderate 3-High

CORE ELECTIVE – 4

CECT124 Introduction of Internet of Things (IOT)

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Understand the history of computer networking and internet protocols.
CO2	Learn in depth about sensors and communication protocols.
CO3	Study fundamentals of IoT and its application in construction industry.
CO4	Design sensor networks for different construction projects/problems.
CO5	Explore case studies of application of IoT in smart infrastructure.

2. Syllabus

- **FUNDAMENTALS OF NETWORKING** **(07 Hours)**
  Understanding of network and internet, ipv4, ipv6, the network edge, the network core, understanding of delay, loss and throughput in the packet switching network, protocols layers and their service model, history of the computer network.

- **SENSOR NETWORK AND COMMUNICATION PROTOCOL** **(07 Hours)**
  Sensors- classes, types, errors, application and construction case study Actuators -types, application and case study, communication protocols, types of sensor networks, node behaviour, coverage, UAV networks.

- **INTRODUCTION TO IOT** **(08 Hours)**
  Introduction to Internet of Things, concept and fundamental understanding, application and connectivity terminologies, IoT components, addressing in IoT, challenges in IoT applications, construction industry application, case studies, Machine-to-Machine communications, interoperability in IoT.

- **PROGRAMMING** **(08 Hours)**
  Introduction to Arduino programming, integration of sensors and actuators with Arduino, Introduction to python programming, python library for Raspberry Pi, implementation of construction project with Raspberry Pi.

- **DATA HANDLING AND ANALYTICS WITH CLOUD COMPUTING** **(07 Hours)**

Smart cities and smart homes, smart grid, agriculture, healthcare, activity monitoring, construction.

(Total Lectures: 45 hours)

3. References

1. Raj, P., & Raman, A. C. (2017). *The Internet of Things: Enabling technologies, platforms, and use cases*. Auerbach Publications.
2. Bahga, A., & Madisetti, V. (2014). *Internet of Things: A hands-on approach*. Vpt.
3. Kurose, J. F. (2005). *Computer networking: A top-down approach featuring the internet, 3/E*. Pearson Education India.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	2	2	3	3
CO2	1	1	1	2	2	1
CO3	3	1	3	3	3	3
CO4	2	2	3	2	3	3
CO5	3	1	3	3	3	3

1-Low 2-Moderate 3-High

CORE ELECTIVE – 4

CECT126 Masonry Design

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Gain knowledge about masonry properties.
CO2	Understand different masonry elements and their behaviour.
CO3	Analyze structural components of unreinforced masonry walls subjected to vertical (gravity) and lateral loads due to wind and earthquakes.
CO4	Design structural components of unreinforced masonry walls subjected to vertical (gravity) and lateral loads due to wind and earthquakes.
CO5	Analyze structural components of reinforced and confined masonry walls subjected to vertical (gravity) and lateral loads due to wind and earthquakes.

2. Syllabus

- **BASIC MATERIAL PROPERTIES** **(10 Hours)**
  Bricks, brick masonry, mortar, bonds, stones, stone masonry, block masonry.

- **MASONRY ELEMENTS** **(10 Hours)**
  Cavity walls, retaining walls, masonry arches, masonry domes, fire bricks, chases, recesses, holes, brick nogging, dhajji walling, window sills, copings.

- **STRUCTURAL DESIGN OF UNREINFORCED MASONRY ELEMENTS** **(15 Hours)**
  Basic structural behaviour, design considerations, slenderness ratio, eccentricity, strength design of unreinforced masonry elements, allowable stress design of unreinforced masonry elements, design of low-rise bearing wall buildings.

- **REINFORCED AND CONFINED MASONRY** **(10 Hours)**
  Introduction to reinforced masonry, introduction to confined masonry.

(Total Lectures: 45 hours)

3. References

1. Brzev, S., and Mitra, K. (2018). *Earthquake-resistant confined masonry construction.* Third Edition, National Information Centre for Earthquake Engineering, IIT Kanpur.

2. Jagadish, K. S. (2015). *Structural masonry*. I. K. International Publishing House Pvt. Ltd., New Delhi, India.
3. Hatzinikolas, M., Korany, Y., and Brzev, S. (2015). *Masonry design for engineers and architects*. Fourth Edition, Canadian Masonry Publications.
4. Klinger, R. (2010). *Masonry structural design*. McGraw-Hill Education.
5. SP 20. (1991). *Handbook on Masonry Design and Construction*. BIS.
6. IS 2212 (1991). Code of Practice for brickworks. BIS.Construction and Demolition Waste Management Rules, 2016, MoEF&CC

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	2	2	3	2	1
CO2	1	2	2	3	2	1
CO3	3	3	3	3	3	1
CO4	3	3	3	3	3	1
CO5	2	3	3	3	2	1

1-Low 2-Moderate 3-High

CORE ELECTIVE – 4

CEGT221 Tunnelling and Underground Structures

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Comprehend the design aspects of various underground structures in soil and rockmass.
CO2	Identify the excavation methods for construction of underground structures in different ground conditions.
CO3	Analyze the underground structures in rock and soil using elastic and elastoplastic solutions.
CO4	Appraise the underground structure using empirical, observational, analytical and numerical approaches.
CO5	Design the support and safety system for underground structures.

2. Syllabus

- **INTRODUCTION** **(06 Hours)**

  Introduction to underground space and tunnelling, History, Tunnelling challenges, Types and classification of underground opening, Factors affecting design, Design methodology, Functional aspects, Size and shapes, Support systems, Codal provisions.

- **EXCAVATION METHOD AND MACHINERY** **(10 Hours)**

  Drilling and blasting for underground and open excavations, blast operation planning, explosive products, blast design, controlled blasting techniques, blasting damage and control, safe practices with explosives and shots. tunnel driving techniques, tbm techniques, bottom up and bottom down method, tunnelling in difficult ground condition, underground supports, theory of arching, rock loads and loads on tunnel linings, safety aspects, case histories.

- **ANALYSIS AND DESIGN OF UNDERGROUND OPENININGS** **(12 Hours)**

  Analysis of underground openings, stresses around different shapes, initial state of stresses, closed form solutions, bem, fem, design based on analytical methods, empirical methods based on rsr, rmr, q systems, observational method- natm, convergence-confinement method, design based on wedge failure and key block analysis, design of shafts and hydraulic tunnels.

- **DESIGN OF SUPPORT SYSTEM** **(09 Hours)**
  Tunnel support systems, different type of supports, standup time, ground reaction curve, stability of excavation face and tunnel portals, surface settlement due to underground works, ground subsidence study, use of appropriate software packages, shotcreting including some case histories, underground instrumentation and monitoring.

- **TUNNEL HEALTH AND SAFETY ISSUES** **(08 Hours)**
  Construction methods, ventilation, de-watering, control and monitoring system: services, operations and maintenance, lighting: specifications, maintenance, emergency lighting, power supply and distribution, water supply and distribution, safety provisions, localized hazards, fire hazards in highway tunnels, rapid transit tunnels. surveillance and control system for highway tunnels. tunnel finish, rehabilitation: inspection methods, repairs, tunnel construction contracting.

(Total Lectures: 45 hours)

3. References

1. Ramamurthy T. (2010). *Engineering in Rocks for Slopes, Foundation and tunnels*. Prentice Hall of India Pvt Ltd, New Delhi.
2. Chapman D., Metje, N., & Stark, A. (2010). *Introduction to tunnel construction.* Spon Press, Taylor and Francis.
3. Kolymbas, D. (2008). *Tunneling and tunnel mechanics: A rational approach to tunnelling.* Springer Publications.
4. Brady, B. H. G. and Brown, E. T. (2006). *Rock mechanics for underground mining.* Springer Publication.
5. Hoek, E. and Brown, E. T. (2005). *Underground excavations in rock.* The Institute of mining and metallurgy.
6. Goodman, R. E. (1989). *Introduction to Rock Mechanics*. John Wiley and Sons.
7. Obert, L. and Duvall, W.I. (1967). *Rock mechanics and the design of structures in rock.* John Wiley and Sons.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	2	2	2	2	1
CO2	2	2	3	3	2	1
CO3	2	3	3	2	2	2
CO4	3	3	3	2	2	2
CO5	3	3	3	3	3	2

1-Low 2-Moderate 3-High

CORE ELECTIVE – 4

CETP127 Operation and Maintenance Management of Pavements

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Comprehend the maintenance management program of pavement by prioritizing the need for maintenance.
CO2	Evaluate the functional and structural condition of existing pavement.
CO3	Identify appropriate tools for pavement evaluation.
CO4	Examine the need for rehabilitation of pavement.
CO5	Design the overlays for the existing pavement using various approaches using BBD and FWD.

2. Syllabus

- **INTRODUCTION** **(09 Hours)**

  Operation and maintenance (O&M) of the project highway, Model Concession Agreement (MCA) for various types of PPP projects, management and organization, project cycle, levels of management, administration and logistics, site management, road maintenance, approach, organization, management activities

- **OPERATIONAL MANAGEMENT ACTIVITIES** **(09 Hours)**

  Road inventory, assessment of maintenance requirements, drainage, running surface structures, setting priorities, planning maintenance works, implementation, work activities and task rates, tools for maintenance works, reporting and monitoring

- **DISTRESS MEASURING EQUIPMENT** **(09 Hours)**

  Functional and structural evaluation, function parameters such as roughness, distress, rutting, skid resistance, etc. testing using conventional and NSV techniques, structural parameters such as structural capacity, Benkelman beam, bump integrator, demonstration of equipment for dynamic testing of pavements (LWD) - pavement skid resistance measuring equipment, fatigue testing equipment

- **DESIGN OF OVERLAYS** **(09 Hours)**

  Types of overlays, design methodologies, flexible overlays, rigid overlays, design of overlay by Benkelman beam and falling weight deflectometer, asphalt institute method, portland cement association method, AASHTO method, use of geosynthetics in pavement overlays.

- **PAVEMENT MANAGEMENT SYSTEM** **(09 Hours)**
  Development of pavement management system: concepts of pavement management systems, pavement performance prediction, concepts, modeling techniques, structural conditional deterioration models, mechanistic and empirical models, functional condition deterioration models, unevenness deterioration models, and other models, ranking, and optimization methodologies

(Total Lectures: 45 hours)

3. References

1. Huang Y.H. (2004). *Design of functional pavements*. Pearson Prentice Hall.
2. Kadiyali L.R. (2003). *Principles & Practice of Highway Engineering*, Khanna Publishers.
3. Hass, R., Hudson, W.R., & Zaniewski, J. (1994). *Modern Pavement Management,* Krieger.
4. Yoder, E.J. and Witczak, M.W. (1975). *Principles of Pavement Design*. John Wiley and sons.
5. Khanna S.K., Justo C.E.G. (1971). *Highway Engineering*. Nem Chand & Bros., Roorkee.
6. Relevant IRC code & Infrastructure development from Planning Commission of India Publication, MORTHs Publications.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	2	1	3	1
CO2	3	1	2	1	1	1
CO3	3	1	1	3	2	1
CO4	3	1	1	3	2	1
CO5	3	3	3	1	1	1

1-Low 2-Moderate 3-High

OPEN ELECTIVE

CECS175 AI/ML Based Applications in Civil Engineering

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Comprehend the basic principles of artificial intelligence (AI) and machine learning (ML) algorithms.
CO2	Understanding Data collection and management tools and techniques for AI/ML application to Civil Engineering.
CO3	Derive the need and benefits of using AI/ML algorithms for developing applications in Civil Engineering using big-data analysis.
CO4	Solve the real-life problems in Civil Engineering using real-time data collection and big-data analysis involving AI/ML tools.
CO5	Evaluate the performance of different AI/ML algorithms towards a given application in civil engineering.

2. Syllabus

- **INTRODUCTION TO MACHINE LEARNING (08 Hours)**

  Machine Learning Basics: Data Collection, Data Management, Big data, taxonomy of machine learning algorithms, Supervised Learning: Classification, Bayesian Classifier, K-nearest Neighbours, Regression- Linear Regression, Multivariate Regression, Logistic regression. Support Vector Machine (SVM) Algorithm. Unsupervised Learning: Clustering- K-means clustering algorithm and Hierarchical clustering algorithm. Reinforcement Learning: Q-Learning algorithm.

- **DATA COLLECTION APPARATUSES (08 Hours)**

  Type of data sources, types of data, types of sensors, Edge-devices, Introduction to microcontrollers, data communication protocols, cloud storage and cloud computing, local server setup, cloud server setup, introduction to python, introduction to django server, database setup.

- **APPLICATIONS IN CIVIL ENGINEERING (15 Hours)**

  Intelligent Transportation systems, smart mobility, shared mobility, Mobility as a Service (MaaS), Real-time data monitoring, Structural health monitoring, Fire resistance evaluation of structures, automation in water resource management, Water quality monitoring, water distribution system monitoring, air and noise pollution monitoring, Rainfall-runoff modelling, Climate change monitoring, Soil liquefaction, Forecasting foundation related parameters, Building occupancy modelling, Building information modelling, Energy demand prediction, Predictive maintenance of equipment, roads and buildings.

- **APPLICATION PART I: DATA COLLECTION AND MANAGEMENT** **(07 Hours)**

  Image processing for real time applications in Civil Engineering, Description of available database across specialisations, Selection of sensors and microcontroller, Integration of sensors with Edge-device, Programming of Edge-devices, Programming of server in Django framework, Collection of sensor data and storing to Database, Cloud computing.

- **APPLICATION PART II: BIG DATA ANALYSIS** **(07 Hours)**

  Selecting the appropriate ML algorithm for analysis, Data Processing, Analysing the importance of each variable in decision making, and Analysis of processed data.

(Total Lectures: 45 hours)

3. References

1. Pradhan M., Kumar U.D. (2020). *Machine Learning using Python*. Wiley.
2. Soldatos, J. (2017). *Building Blocks for IoT Analytics Internet-of-Things Analytics* (p. 292). Taylor & Francis.
3. Farrar, C. R., & Worden, K. (2012). *Structural health monitoring: a machine learning perspective*. John Wiley & Sons.
4. Washington, S., Karlaftis, M. G., Mannering, F., & Anastasopoulos, P. (2020). *Statistical and econometric methods for transportation data analysis*. Chapman and Hall/CRC.
5. Johnson, R. A., & Wichern, D. W. (2002). Applied multivariate statistical analysis.

4. Other Materials

1. Arduino-ESP32 (Release 2.0.2), Espressif, 2022.

5. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	3
CO2	3	2	3	3	3	3
CO3	3	3	3	2	3	3
CO4	3	3	3	2	3	3
CO5	3	2	3	2	3	3

1-Low 2-Moderate 3-High

OPEN ELECTIVE

CECT172 Project Management for Engineers

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Understand the various aspects of project management critical for implementation of projects.
CO2	Demonstrate construction planning, scheduling, and controlling.
CO3	Apply techniques of total quality assurance and quality control programme and cost implication.
CO4	Assess project costs, risks and claims.
CO5	Comprehend fundamentals of contract administration and supply chain management.

2. Syllabus

- **INTRODUCTION TO PROJECT MANAGEMENT (04 Hours)**

  About projects, significance of projects in nation building, about project management, project organizations, project acquisition and execution, business development and sales, tendering and cost estimation.

- **OVERALL PROJECT MANAGEMENT PLAN AND SCOPE MANAGEMENT (08 Hours)**

  Scope of work, key deliverables and project requirements, completion time and key milestones, project cost and budget, performance parameters and guarantees, scope management, developing scope management plan, understanding technical specifications and project requirements, work breakdown structure, creating scope baseline, controlling scope.

- **PROJECT PLANNING AND SCHEDULING (08 Hours)**

  About schedule management, developing schedule management plan, understanding contractual schedule and milestones, estimation of activities' duration, sequencing and relationships, techniques in planning and scheduling, bar chart, Gantt chart, networks, PERT and PERT analysis, CPM network, baseline, monitor and control schedule.

- **COSTING AND BUDGETING (04 Hours)**

  Review pre-tender cost estimation, preparation of detailed cost estimate, budget and approval process, cost baseline, monitor and control costs, variance analysis, earned value analysis.

- **QUALITY MANAGEMENT** **(04 Hours)**
  Objectives, Quality Control and assurance, tools used in quality control, quality management, perform quality assurance activities, monitor and control quality.

- **PROJECT RISK MANAGEMENT** **(05 Hours)**
  Introduction, different types of risks, risk management, risk appetite and threshold limit, risk profile, risk management process, risk identification, risk analysis (qualitative and quantitative), risk response, monitor risks, prepare and update risk.

- **CONTRACTS AND CLAIMS MANAGEMENT** **(05 Hours)**
  Basic concepts and definitions, contract classifications, understanding contract clauses, contract administration and interpretation, change management, claims management, dispute resolution.

- **SUPPLY CHAIN MANAGEMENT** **(04 Hours)**
  About subcontracting, benefits and risks, subcontracting strategy and plan, subcontract formation and administration, performance monitoring, procurement process, procurement contracts, risks and benefits, digitization.

- **PROJECT CLOSURE** **(03 Hours)**
  Completion of key deliverables, closure of purchase orders and subcontracts, commercial closure, demobilization of resources, project hand-over, closure of main contracts.

(Total Lectures: 45 hours)

3. References

1. Harris, F., McCaffer, R., Baldwin, A., & Edum-Fotwe, F. (2021). *Modern construction management*. John Wiley & Sons.
2. Jha, K. N. (2015). *Construction Project Management*. 2nd Edition, Pearson Publishers.
3. Whyte, A. (2015). *Integrated Design and cost for civil Engineers*. CRC Press, Taylor and Francis Group.
4. Goetsch, D. L. (2015). *Project Management for construction*. Pearson publishers.
5. Baldwin, A., & Bordoli, D. (2014). *A Handbook for Construction Planning and*

Scheduling. Blackwell Publishers.

6. Knutson, K., Schexnayder, C. J., Fiori, C. and Mayo, R. E. (2013). *Construction Management Fundamentals*. MCGraw Hill Publishers.
7. Ottoson, H. (2013). *Practical project management for building and construction*. CRC Press, Taylor and Francis.
8. Fewings, P. (2011). *Construction Project Management - An integrated approach*. Taylor and Francis.
9. Mubarak, S. (2010). *Construction project scheduling and control*. Second edition, John Wiley and sons.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	3	3	3	2
CO2	3	1	2	3	3	3
CO3	3	1	3	3	2	2
CO4	3	1	3	3	3	2
CO5	3	1	3	3	2	2

1-Low 2-Moderate 3-High

OPEN ELECTIVE

CECT174 Project Appraisal and Finance (3-0-0)

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Learn the basics of measurement of project performance.
CO2	Understand the various discounting and compounding criteria.
CO3	Familiarize with accounting fundamentals.
CO4	Study the theories of working capital management.
CO5	Apply financial methods in making capital investment decisions in projects.

2. Syllabus

- **PROJECT FORMULATION** **(10 Hours)**
  Generation and screening of project ideas, project identification, preliminary analysis, market, technical, financial, economic and ecological-pre-feasibility report and its clearance, project estimates and techno-economic feasibility report, detailed project report, different project clearances required.

- **PROJECT APPRAISAL** **(10 Hours)**
  NPV, BCR, IRR, ARR, urgency-payback period, assessment of various methods, Indian practice of investment appraisal, international practice of appraisal, analysis of risk, different methods for selection of a project and risk analysis in practice, ownership structures; BOT, BOLT, BOOT models.

- **PROJECT ACCOUNTING** **(09 Hours)**
  Profit and loss, balance sheet, income statement, ratio analysis, depreciation and amortization, preparation of financial statements, inflation accounting and corporate practices in India.

- **WORKING CAPITAL MANAGEMENT** **(08 Hours)**
  Policy for working capital, estimating working capital need, inventory management, account receivable, credit and cash management, managing payments to supplies and outstanding, capital investment decisions, techniques of capital budgeting, cost of capital. Cash flow analysis.

- **LONG TERM FINANCING AND BUDGETING** **(08 Hours)**

  Working of financial institutes in India and abroad, self-financing, stock exchanges, types of securities, borrowings, debentures, types of budgeting, procedure for master budget, key factor, budget manual, and new approach to budgeting, cash flow forecast.

(Total Lectures: 45 hours)

3. References

1. Pandey, I. M. (2021). *Financial Management*. 12th edition, Pearson.
2. Khan, M. Y., & Jain P. K. (2018). *Financial Management*. 8th edition, McGraw Hill Education.
3. Desai, V., & Kaur K. (2015). *Entrepreneurship: Development and Management* Himalaya Publishing House.
4. Desai, V. (2011). *The Dynamics of Entrepreneurial Development and Management*. 6th edition, Himalaya Publishing House.
5. McCarthy, J. F. (2010). *Construction project management - A managerial approach*. Pareto publishers.
6. Maheshwari, S. N. (2002). *Cost and Management Accounting*. Sultan Chand & Sons.
7. Chandra, P. (1995). *Projects Preparation, Appraisals, Budgeting and Implementation*. 3rd Edition, Tata Mc Graw Hill Publishing Co. Ltd.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	2	2	2	2
CO2	2	2	1	2	2	2
CO3	3	2	3	3	2	2
CO4	3	2	2	3	1	2
CO5	3	2	2	3	2	2

1-Low 2-Moderate 3-High

OPEN ELECTIVE

CECT176 Offshore and Marine Projects Management

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Recognize and manage key design and operational interfaces between the major components of offshore facilities systems.
CO2	Introduce the fundamentals of offshore engineering, and marine engineering.
CO3	Provide latest engineering knowledge in the context of offshore survey.
CO4	Understand the concept, significance and basic knowledge of asset management.
CO5	Apply useful techniques to identify, analyze, mitigate and monitor risks throughout the project life cycle.

2. Syllabus

- **CONCEPT OF OFFSHORE AND MARINE PROJECT MANAGEMENT** **(14 Hours)**

  Field development concepts, selection and sizing of facility, major systems in subsea development, drilling operations, onshore vs offshore drilling, rules, regulations and environmental considerations (design codes, industry standards and regulations), design basis for offshore oil and gas facilities, modular design and standardization, interfaces and interface management, safety in design and operation, process system (separation system, gas handling system, utility systems), power generation, piping design, electrical, instrumentation and telecommunication design, insulation and trace heating, construction planning and progress reporting, construction site scope, load-out plan and procedures, installation and hook-up, mechanical completion, commissioning, start-up, and handover, decommissioning.

- **FUNDAMENTALS OF OFFSHORE, SUBSEA AND PIPELINE ENGINEERING** **(12 Hours)**

  Offshore oil and gas development, Offshore survey: principles and technologies of offshore survey, potential flow theory and overview of ocean environmental conditions, Other offshore development: ocean renewable energy, decommissioning and ocean space utilization, Subsea communication and control, Overview of Autonomous Underwater Vehicles (AUV) and Remotely Operated Vehicles (ROV), Reservoir geochemistry and chemical processing, Fundamentals of pipelines and flow assurance, Drilling Engineering, Subsea structures, installation and field architecture.

- **ASSET MANAGEMENT IN MARINE ENGINEERING (09 Hours)**
  Facility reliability, FMECA and fault tree analysis of marine components, NDT techniques, condition monitoring methods and advanced signal processing and fault diagnosis techniques, maintenance strategies.

- **OFFSHORE AND MARINE PROJECTS RISKS MANAGEMENT (10 Hours)**
  Risk Management Framework and Planning, plan the approach to offshore project risk management, project risk identification process, project risk assessment and quantification processes, risk analysis tools and techniques, concepts of risk including quantitative, semi-quantitative and qualitative approaches, ALARP criteria, individual and societal risk factors, project risk rating and prioritising, use of failure modes and effects and criticality analysis to identify system and component failure. Hazard and operability studies to identify hazards in offshore and subsea processes, risk response plan development, risk response control, risk response plan execution, evaluating risk response results.

(Total Lectures: 45 hours)

3. References

1. Whyte, A. (2015). *Integrated Design and cost for civil Engineers*. CRC Press, Taylor and Francis Group.
2. Jha, K. N. (2015). *Construction Project Management*. 2nd Edition, Pearson Publishers.
3. Whyte, A. (2015). *Integrated Design and cost for civil Engineers*. CRC Press, Taylor and Francis Group.
4. Goetsch, D. L. (2015). *Project Management for construction*. Pearson publishers.
5. Baldwin, A. and Bordoli, D. (2014). *A Handbook for Construction Planning and Scheduling*. Blackwell Publishers.
6. Knutson, K. Schexnayder, C. J. Fiori, C., & Mayo, R. E. (2013). *Construction Management Fundamentals*. MCGraw Hill Publishers.
7. Ottoson, H. (2013). *Practical project management for building and construction*. CRC Press, Taylor and Francis.
8. Fewings, P. (2011). *Construction Project Management - An integrated approach*. Taylor and Francis.

9. Mubarak, S. (2010). *Construction project scheduling and control*. Second edition, John Wiley and Sons.
10. Harris, F., McCaffer, R., Baldwin, A., & Edum-Fotwe, F. (2021). *Modern construction management*. John Wiley & Sons.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	2
CO2	3	1	2	3	3	3
CO3	3	1	2	3	3	2
CO4	3	1	3	3	3	2
CO5	3	1	3	3	2	1

1-Low 2-Moderate 3-High

OPEN ELECTIVE

CECT178 Quantitative Methods

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Learn basics of statistical methods and modelling techniques.
CO2	Demonstrate the ability to analyze data using operation research methods.
CO3	Understand simulation models and inventory control methods for production management.
CO4	Be aware of various deterministic and probabilistic decision-making theories.
CO5	Study cost concepts and break-even analysis in managerial economics.

2. Syllabus

- **STATISTICS** **(07 Hours)**

  Probability, Sampling, Uni-square and analysis of variance, simple regression and correlation, multiple regression and modeling techniques.

- **OPERATION RESEARCH** **(10 Hours)**

  Introduction to operations research, linear programming, graphical and simplex methods, duality and post-optimality analysis, transportation and assignment problems, queuing theory, queuing model, optimization techniques, model formulation, models, sensitivity analysis, non-linear programming problem – Kuhn-Tucjker conditions min cost flow problems – max flow problem.

- **PRODUCTION MANAGEMENT** **(10 Hours)**

  Inventory control – probabilistic and deterministic, EOQ, quantity discounts, safety stock-replacement theory-modification and improvement on PERT and CPM, simulation models, geometric programming, scheduling and sequencing – single server and multiple server models.

- **DECISION THEORY** **(09 Hours)**

  Decision theory, decision rules, decision making under conditions of certainty, risk and uncertainty, decision trees utility theory, decision making techniques. Deterministic and probabilistic situation, single and multiple person decision making.

- **MANAGERIAL ECONOMICS** **(09 Hours)**

  Cost concepts, break-even analysis, pricing techniques, game theory and its applications, competitive models, single and multi-channel problems, sequencing models, dynamic programming, flow in networks, elementary graph theory, parametric programming.

(Total Lectures: 45 hours)

3. References

1. Winston, L. (2003). *Operations Research: Application and Algorithms*. 4th Edition. Kent P.W.S.
2. Vohra, N. D. (2017). *Quantitative technique in Management*. 5th Edition. McGraw Hill Publication.
3. Bazaraa, S., Jarvis J. J., & Sherali, H. D. (2009). *Linear Programming and Network Flows*. 4th Edition. Wiley.
4. Deb, K. (1995). *Optimization for Engineering Design*. Prentice Hall of India.
5. Levin R. and Rubin D.S. (1993). *Quantitative Approach to Management*. 8th Edition. McGraw Hill Publication.
6. https://www.shastriinstitute.org/sites/default/files/Syllabus.pdf 118

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	2	1	1	2
CO2	3	3	2	1	1	2
CO3	3	2	2	2	2	2
CO4	3	2	2	1	2	2
CO5	3	2	2	2	2	2

1-Low 2-Moderate 3-High

OPEN ELECTIVE

CECT180 Resilient and Sustainable Infrastructure

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Understand in depth the framework and techniques of infrastructure asset management.
CO2	Study risk analysis techniques in advanced infrastructure asset management.
CO3	Explore tools and techniques of performance management.
CO4	Correlate infrastructure sustainability management tools and techniques with real world problems.
CO5	Correlate infrastructure resiliency management tools and techniques with real world problems.

2. Syllabus

- **INTRODUCTION OF INFRASTRUCTURE ASSET MANAGEMENT** **(09 Hours)**

  Infrastructure asset management definitions, framework and primers, infrastructure asset management steps process and techniques, infrastructure asset management hierarch, inventory, and register.

- **ADVANCED INFRASTRUCTURE ASSET MANAGEMENT** **(09 Hours)**

  Advanced infrastructure management: likelihood of failure, advanced infrastructure management: likelihood of failure, advanced infrastructure management: risk analysis and management.

- **PERFORMANCE OF INFRASTRUCTURE ASSET MANAGEMENT** **(09 Hours)**

  Infrastructure performance management definition, framework and primers, infrastructure performance metrics, indices, tools and techniques, infrastructure performance management and real-world application.

- **INFRASTRUCTURE ASSET MANAGEMENT – SUSTAINABILITY (09 Hours)**

  Infrastructure sustainability management definition, framework and primers, infrastructure sustainability metrics, indices, tools and techniques, infrastructure sustainability management and real-world application.

- **INFRASTRUCTURE ASSET MANAGEMENT - RESILIENCY (09 Hours)**
  Infrastructure resiliency management definition, framework and primers, infrastructure resiliency metrics, indices, tools and techniques, infrastructure resiliency management and real-world application.

(Total Lectures: 45 hours)

3. References

1. Pollalis, S. (2016). *Planning sustainable cities: an infrastructure-based approach*. Routledge.
2. Gopalakrishnan, K., & Peeta, S. (Eds.). (2010). *Sustainable and resilient critical infrastructure systems: simulation, modeling, and intelligent engineering*. Springer Science & Business Media.
3. Novotny, V., & Brown, P. (Eds.). (2007). *Cities of the future*. IWA publishing.
4. Elzen, B., Geels, F. W., & Green, K. (Eds.). (2004). *System innovation and the transition to sustainability: theory, evidence and policy*. Edward Elgar Publishing.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	2	2	2	2	2
CO2	3	2	3	3	3	2
CO3	2	2	3	3	3	3
CO4	2	2	3	3	3	3
CO5	2	2	3	3	3	3

1-Low 2-Moderate 3-High

OPEN ELECTIVE

CECT182 Smart Infrastructure System

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Learn basic concepts of modern cities and develop sustainable smart solutions.
CO2	Study surveillance and traffic systems for smart security infrastructure.
CO3	Explore wired and wireless network systems for smart infrastructure.
CO4	Understand the smart transport system for smart cities and its application.
CO5	Refer case studies of various countries for smart and renewable energy systems.

2. Syllabus

- **MODERN CITIES – CHARACTERISTICS** **(09 Hours)**
  Three layers concept of modern cities (Urban infrastructure, facility and service layers), Understanding the need to reduce carbon emissions and developing sustainable smart solutions. Four facets of smart solutions - Physical, Institutional, Social and Economic Infrastructure; Framework of public information system in smart cities.

- **SMART SECURITY INFRASTRUCTURE** **(09 Hours)**
  City surveillance systems, Intelligent Traffic Management Systems, Emergency Response systems and smart solutions to handle crisis management.

- **SMART TELE COMMUNICATIONS INFRASTRUCTURE** **(09 Hours)**
  Wired and wireless network systems, Role of satellite communication, Wi-Fi and RF systems in smart communication, Optical Fiber Cable and DWDM (Dense Wave Division Multiplexing), IPMPCS (Multi Protocol Cable Switching) solutions.

- **SMART TRASNPORT INFRASTRUCTURE** **(09 Hours)**
  Smart transportation, Logistics, Real time Information systems, traffic information management, smart solutions for water supply and waste water engineering; remote sensing and GIS technology.

- **ENERGY SOLUTIONS** **(09 Hours)**
  Renewable energy, Smart grid systems, reducing carbon emissions without compromising on convenience of users, Community Energy Management systems,

Energy on wheels, H2H and V2H (Home to Home and Vehicle to Home) Energy solutions, smart meters, case studies-Japan and Europe countries.

(Total Lectures: 45 hours)

3. References

1. Various papers edited by T.Chou in his book on Remote sensing and smart city WTS press
2. Concept oriented research and development in Information Technology Edited by Kinji Mori WILEY Publ.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	2	2	3	2	3
CO2	2	2	2	3	3	3
CO3	2	2	2	2	2	3
CO4	2	2	2	2	2	1
CO5	3	2	3	3	3	2

1-Low 2-Moderate 3-High

OPEN ELECTIVE

CECT184 Building Information Modeling (BIM)

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Understand Building Information Modelling and various BIM software systems.
CO2	Explore model-based engineering workflows in building and infrastructure lifecycles.
CO3	Achieve engineering objectives of virtual design and construction in practice.
CO4	Learn construction scheduling, quantity take-offs and run nD simulations using BIM software.
CO5	Utilize BIM for system clash detection and prevention.

2. Syllabus

- **INTRODUCTION OF BIM** **(07 Hours)**

  Introduction to BIM process and integrated project delivery, nD modelling, BIM software systems and guidelines to choosing different BIM software systems.

- **BASIC MODELLING** **(07 Hours)**

  Introduction of modelling environment and tools, modelling approaches to producing plans, 3D models, views and sections of buildings, creating an initial sample of 3D BIM model using a BIM authoring software, Modelling of building including basic and vital elements, production of plans, views and 3D models, annotations and preparations of sheets for printing and publishing.

- **ADVANCE CONCEPTS** **(08 Hours)**

  Model customizations, elements and materials, creation of internal components, external elements, massing and site modelling, Elements visibility, visualization and walkthroughs, model/information exchange and merging of models.

- **nD MODELLING** **(08 Hours)**

  Introduction to aspects of nD modelling, scheduling and quantity take-offs using BIM-enabled systems and export to spreadsheets, Production of a 4D program in 4D BIM software, cost estimation, producing cost estimates in a 5D BIM software.

- **INTEROPERABILITY IN BIM** **(08 Hours)**

  Basics about interoperability, Export formats and applications, exchange of information through IFC, COBie, BIM 360 Glue, Mobile BIM.

- **ADVANCES IN BIM** **(07 Hours)**

  Clash detection, Overview of clash detection tools, use of software to detect/resolve clashes in a BIM model, project collaboration using cloud/mobile BIM systems and common data environments.

(Total Lectures: 45 hours)

3. References

1. Hardin, Hardin, B., & McCool, D. (2015). *BIM and construction management: proven tools, methods, and workflows*. John Wiley & Sons.
2. Hardin, B., & McCool, D. (2015). *BIM and construction management: proven tools, methods, and workflows*. John Wiley & Sons.
3. Eastman, C. M. (2011). *BIM handbook: A guide to building information modeling for owners, managers, designers, engineers and contractors*. John Wiley & Sons.
4. Kymmell, W. (2008). Building information modeling: Planning and Managing Construction Projects with 4D CAD and Simulations (McGraw-Hill Construction Series): Planning and Managing Construction Projects with 4D CAD and Simulations. McGraw Hill Professional.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	2	2	2	3	3
CO2	2	1	3	2	3	3
CO3	3	2	3	3	3	3
CO4	3	1	2	3	3	3
CO5	3	1	2	3	3	3

1-Low 2-Moderate 3-High

CECT106 Industry 4.0 Lab

L	T	P	C
0	0	4	2

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Study various digital tools and technologies used in construction industry.
CO2	Explore the benefits of REVIT and NavisWorks in construction management.
CO3	Prepare entire model of any residential project in software.
CO4	Learn in-depth about applications of Digital technologies in construction.
CO5	Understanding the impact of Digital tools in construction sector

2. Syllabus

- **INTRODUCTION**

  Introduction to the impact of Industry 4.0 on the construction industry; Understanding the key usage of digital tools in construction owing to rapidly changing technology.

- **MODELLING**

  Exploring the user interface, working with Revit elements; creating a basic floor plan, working with grids and structural columns; adding and modifying walls, loading additional building components; importing and exporting using external files and linking files; creating advanced components, creating and modifying parametric families, viewing the building model, controlling object visibility, creating and modifying section and elevation views; developing the building model, creating and modifying floors, ceilings, roofs and curtain wall; detailing and drafting, duplicating views, creating elevations, creating section structural works, floor framing, working with roofs, working with structural steel frames; working with sloped beams, working with floor decks, working with foundation slabs and slabs, footings and grade beams, managing revisions, user interface and file organization.

- **MODEL DEVELOPMENT**

  Exploring the user interface, working with NavisWorks elements and file organization; overriding transparency, colour, and object/model location; importing 3D files, how to import and append 3D model file; understanding NavisWorks file formats, object enablers; navigation, zooming, panning, walking around sectioning, moving objects, hiding layers and objects, establishing selection sets; viewpoints, establishing and organizing custom, viewpoints, publishing the model file and viewpoints, internal/in-house clash detection, 4D simulation.

- **DIGITAL TOOLS FOR PROJECT MANAGEMENT**

Virtual environment: Introduction to AR and VR; key applications and usage, basic software requirements and tools, tracking and sensors, design principles and application in construction industry.

Spatial data: Introduction to spatial data collection through GIS software and tools like ArcGIS, QGIS; data sources, and analysis techniques; Geostatistical analysis including interpolation method, hotspot analysis and trend analysis, application of GIS in construction.

Drones: Introduction to drone technology for construction projects, regulatory framework for usage, safety and ethical considerations, application in site surveying, monitoring and inspection, data processing and analysis.

Real-time data collection: Components of IoT including sensors, User interface, Actuators, Data processing, connectivity; Application of IoT in construction industry for data collection and transmission, IoT devices used for various applications; types of sensors, IoT protocols, challenges and solutions in future usage.

3D-printing: Introduction to Sustainable construction techniques, materials in usage, technologies involved, modelling software design principles, current scenario of application.

Artificial Intelligence: Use of AI in project management, introduction of algorithms, basic theory, training and learning tools, coding.

Term work based on above exercises with continuous evaluation during the course of the semester.

3. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	2	3	2	2
CO2	3	2	2	3	2	3
CO3	3	3	3	3	3	3
CO4	3	3	2	3	3	3
CO5	3	2	2	3	2	2

1-Low 2-Moderate 3-High

CECT108 Mini Project

L	T	P	C
0	0	2	1

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Identify problems that have relevance to the current industrial needs and be aware about current innovative practices and technology.
CO2	Conduct literature survey in the chosen field and discover research gap from the existing literature.
CO3	Apply various engineering and management topics according to real site conditions.
CO4	Identify the problems which can occur during the execution of the project and find solutions to the problems using various construction management tools and techniques.
CO5	Develop technical writing, presentation and communication skills.

2. Syllabus

Mini project is aimed at identification of the research area and formulation of the research objectives for a particular study. Students are expected to carry out independent research work on the chosen topic and submit duly computer typed reports, present and participate in subject wise group discussion. The work at this stage may involve extensive review of literature, identify research gaps, case study, identify research problems, field data collection and analysis and be aware of current technologies.

3. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	3
CO2	3	3	3	3	3	2
CO3	3	2	2	3	2	3
CO4	3	2	3	3	2	1
CO5	3	3	2	3	3	3

1-Low 2-Moderate 3-High

Semester III

CECT201 Summer Training

L	T	P	C
0	0	0	2

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Understand the organisational structure, their function along with the services of organisation.
CO2	Analyze the gap between theoretical knowledge and actual practices done on site.
CO3	Familiarize with various construction techniques used in construction industry.
CO4	Study the assumptions and approximations adopted in practices while dealing with live engineering issues.
CO5	Understand the roles and responsibilities of a construction project manager.

2. Syllabus

Six/Eight-week summer training on construction projects, is to be carried at National/State/Local Government Project level after the Second Semester Examination and prior to opening of Third Semester and project report on the same is to be prepared and submitted duly certified by the Project Organization as well as presented in institute.

3. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	1	3	2	2
CO2	3	1	2	2	2	2
CO3	1	2	3	2	2	2
CO4	1	1	3	3	3	2
CO5	2	1	3	3	3	3

1-Low 2-Moderate 3-High

CECT295 Dissertation Preliminaries

L	T	P	C
0	0	0	14

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Identify research gap by conducting a persistent literature review.
CO2	Construct a problem statement based on identified research gap.
CO3	Devise objective and scope that bridges the identified gap.
CO4	Develop methodology including tools and techniques to be used in alignment with the desired scope and objective.
CO5	Prepare a detailed report and presentation to improve technical writing and presentation skills.

2. Syllabus

Dissertation preliminaries should clearly identify the goals and objectives and scope of the dissertation work taken up by the candidate. The focus is on data identification and proposed field surveys, questionnaire design, sample size decision. The study methodology and literature review on the dissertation topic is to be completed and a typed report is to be finalized in consultation with dissertation supervisor and submitted for the assessment at the end of the semester.

3. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	3
CO2	2	3	3	2	3	3
CO3	3	3	2	3	3	3
CO4	3	3	3	3	3	3
CO5	3	3	2	3	3	3

1-Low 2-Moderate 3-High

Semester IV

CECT296 Dissertation

L	T	P	C
0	0	0	20

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Enhance the ability for conception of the idea by conducing thorough research.
CO2	Improve the ability and confidence to undertake field studies, data collection and analysis.
CO3	Develop an ability of preparing research proposal.
CO4	Organize the research work in order to prepare dissertation report.
CO5	Defend the research work through presentation demonstrating comprehensive understanding of the problem and research conclusions.

2. Syllabus

- The preliminary dissertation work initiated in Third semester is further extended over fourth semester to cover up the field studies, data analysis, modeling, if any and research finding followed by conclusion etc.
- The main objective of the dissertation work is to provide scope for original and independent research to express the ability of using analytical approach or technical investigation.
- Thesis is to be prepared by each student under the guidance of faculty supervisor and finally submitted in four typed bound sets as per the specified time.
- The assessment of the dissertation work will be carried out in two stages, first during the semester for 160 marks, and final viva-voce exam for 240 marks at the end of the semester.

3. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	2
CO2	3	2	3	3	2	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3

1-Low 2-Moderate 3-High

Teaching Scheme

M.Tech in Environmental Engineering

Semester wise credit

Sr. no	Semester	Credit
1.	First	21
2.	Second	21
3.	Third	21-23
4.	Fourth	20
	Total	83-86

Teaching Scheme

M.Tech in Environmental Engineering

Sr. No.	Subject	Code	Scheme L-T-P	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
				Th.	T	P		
				Marks	Marks	Marks		
	First Semester							
1	Physico-Chemical Processes	CEEN101	3-1-0	100	25	-	4	70
2	Biological Processes	CEEN103	3-1-0	100	25	-	4	70
3	Environmental Chemistry and Microbiology	CEEN105	4-0-0	100	-	-	4	70
4	Elective -1		3-0-0	100	-	-	3	55
5	Elective – 2		3-0-0	100	-	-	3	55
6.	Environmental Engg. Lab	CEEN107	0-0-4	100	-	-	2	70
7.	Seminar	CEEN109	0-0-2	100	-	-	1	40
8.	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	CEENV191 CEENP191	0-0-10				5	200 (20 x 10)
						Total	**21**	**390**
	Second Semester							
1	Solid and Hazardous Waste Management	CEEN102	3-1-0	100	25	-	4	70
2	Air Pollution and Control	CEEN104	3-1-0	100	25	-	4	70
3	Elective -3		3-0-0	100	-	-	3	55
4	Elective -4		3-0-0	100	-	-	3	55
5	Institute Elective*****		3-0-0	100	-	-	3	55
6	Mini Project		$$##nXX	100	-	-	2	70
7.	Advance Environmental Engg. Lab	CEEN106	0-0-4	100	-	-	2	70
						Total	**21**	**445**
7	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	CEENV192 CEENP192	0-0-10				5	200 (20 x 10)

L: Lecture; T: Tutorial; P: Practical; Th: Theory

*****to be offered to the PG students of other department and other PG Programs with the department.

Subject Code: Core, Electives, Dissertation Preliminary and Dissertation: **$$##nXX;** Vocational Training: **$$##VXX;** Professional Experience: **$$##PXX;**

$$: Department Name; **##**: M.Tech Course Identity; **n**: Year; **XX**: Core (01 to 10), Elective (11 to 70), Institute Elective (71 to 90), Vocational Training (91 to 92), Vocational Training (93 to 94), Dissertation Preliminary (95), Dissertation (96)

XX last digit odd number (for odd semester); XX last digit even number (for even semester)

Calculation of Notional Hours for the subject containing Theory, Tutorial and Practical

Example: 3-1-2: 3*15+1*15+2*15+10 (Exam)= 100

Sr. No.	Subject	Code	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
			Th.	T	P		
			Marks	Marks	Marks		
	Third Semester						
1	MOOC course – I*	φ	-	-	-	3/4	70/80
2	MOOC course – II*	φ	-	-	-	3/4	70/80
3.	Industrial Training		-	-	-	1	-
4	Dissertation Preliminaries	CEEN295	-	-	$350^{\$}$	14	560
			Total			**21-23**	**700-720**
	Fourth Semester						
1	Dissertation	CEEN296	-	-	$600^{\$}$	20	800

$^{\$}$ **Internal**: 40% and **External**: 60%

*Swayam/NPTEL

φ As per 66th IAAC, Dated 20th March, 2024, Resolution No. 66.34 and 61st Senate resolution No. 4, 25th April, 2024

Elective 1

CEEN111Environmental Legislation and Impact Assessment
CEEN113Environmental Hydraulics
CEEN115 GIS and Remote Sensing in Environmental Engineering

Elective 2

CEEN117 Sustainable Waste Management System
CEEN119 Occupational Health, Safety and Environment
CEEN121Advanced Water and Wastewater Treatment

Elective 3

CEEN112 Industrial Waste Management
CEEN114 Environmental System Modelling
CEEN116 Waste-to-Energy Technologies

Elective 4

CEEN118 Noise, Indoor Air and Odour Pollution
CEEN120 Applied Statistics for Engineers
CEEN122 Cleaner Production and Environmental Management System

Institute elective

CEEN111Environmental Legislation and Impact Assessment
CEEN120 Applied Statistics for Engineers
CEEN119 Occupational Health, Safety and Environment
CEEN116Waste-to-Energy Technologies
CEEN271 AI/ML Based Applications in Civil Engineering

Course-wise Detailed Syllabus

SEMESTER – I

CEEN101PHYSICO-CHEMICAL PROCESSES

L	T	P	C
3	1	0	4

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Describe physical and chemical phenomena that form the basis for the design of unit processes.
CO2	Use the theoretical knowledge of corresponding physical and chemical phenomena in the treatment processes.
CO3	Design physico-chemical treatment processes to meet treatment goals for a given pollution scenario.
CO4	Apply advanced treatment processes for treating water and wastewater.
CO5	Develop conceptual schematics for the treatment of water and wastewater.

2. Syllabus

- **INTRODUCTION** **(02 Hours)**

  Physico-chemical processes to control water/wastewater pollution – Flowchart.

- **SEDIMENTATION AND COAGULATION** **(10 Hours)**

  Types of settling and their mathematical analysis – Coagulation: mechanism of coagulation – Colloidal chemistry – Modelling coagulation process – Effect of turbidity and alkalinity – Chemistry of coagulants – Design of coagulation process.

- **FLOW THROUGH BEDS OF SOLIDS** **(12 Hours)**

  Type of filters – Modelling filtration process – Mechanism– Ion exchange units – Contacting towers – Flow through expanded beds – Flow through porous plates and membranes.

- **GAS TRANSFER AND DISINFECTION** **(08 Hours)**

  Mechanism of gas transfer – Film coefficients and equilibrium relationship – Gas disperses – Packed columns – Tray columns – Spray units – Applications in environmental engineering – Disinfection – Mechanisms– Different agents.

- **ADVANCED TREATMENT OPERATIONS** **(13 Hours)**

  Adsorption – Isotherms – Softening – Ion exchange – Removal of specific chemical contaminants such as fluorides, arsenic, nitrates and trace organics. Advanced Oxidation Processes - Membrane processes – Reverse osmosis – Electro-dialysis – Desalination

(TotalLectures:45Hours)

3. References

1. Metcalf, L., & Eddy, H. (2014). Wastewater engineering: Collection, treatment, disposal, and reuse (5th ed.). McGraw-Hill.
2. Wiesmann, U., Choi, I. S., & Dombrowski, E. M. (2018). Fundamentals of biological wastewater treatment (2nd ed.). Wiley.
3. Hendricks, D. (2006). Water treatment unit processes: Physical and chemical. CRC Press.
4. Tchobanoglous, G., Burton, F. L., & Stensel, H. D. (2017). Wastewater engineering: Treatment and reuse (7th ed.). Tata McGraw-Hill.

5. Arceivala, S. J., & Asolekar, S. R. (2007). Wastewater treatment for pollution control and reuse (3rd ed.). Tata McGraw-Hill.
6. Sincero, A. P., & Sincero, G. A. (2008). Environmental engineering: A design approach (2nd ed.). Prentice-Hall.

4. CO-PO-PSO_Mapping

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	2	0	3	2	2	2
CO2	3	0	3	3	3	2
CO3	3	1	3	3	3	2
CO4	3	1	3	3	3	2
CO5	3	2	3	3	3	2

CEEN103 BIOLOGICAL PROCESSES

L	T	P	C
3	1	0	4

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Explain reactions, reactors and biological treatment processes.
CO2	Understand concepts of microbial growth and substrate utilization.
CO3	Differentiate various biological processes.
CO4	Design various biological treatment process units.
CO5	Design nutrient removal through biological processes.

2. Syllabus

- **REACTORS ANDREACTORANALYSIS** **(10 Hours)**
  Reactionsandreactionkinetics–Typesofreactorsandtheiranalysis–Hydrauliccharacteristicsofreactors.
- **KINETICSOFBIOLOGICALGROWTH** **(08 Hours)**
  Nutrition and growth conditions – Effect of environmental conditions–Bacterial growth in terms ofnumbersandmass–Growthcurve–Interpretationofcurve–Substratelimitedgrowth–Monod's expression – Substrate utilization and cell growth – Effect of Endogenous metabolism –Inhibition–Effectoftemperature–Applicationofgrowthandsubstrateremovalkineticstobiological treatment.
- **AEROBICPROCESSES** **(12Hours)**
  Suspended and attached growth systems – Modelling suspended growth – Activated sludgeprocess–Typesandtheirdesignconcepts–Differentattachedgrowthsystemsandtheir designconcepts.–AdvancedBiological Processes like MBR, MBBR, IFAS, Aerobic Granular Sludge Technology.
- **ANAEROBICTREATMENTPROCESSES** **(06Hours)**
  Microbiology–Differenttypes–DesignconsiderationsofUASBandattachedgrowthsystems.
- **NUTRIENTREMOVALANDPONDTREATMENTPROCESSES** **(06 Hours)**
  Biologicalprocessesfornitrogenandphosphorusremoval–NitrificationandDenitrificationprocessesandtheirdesignconcepts–Differentpondtreatmentsystems
- **BIOLOGICALPROCESSESFORSLUDGEPROCESSING** **(03Hours)**
  Anaerobicandaerobicdigestion.

(TotalLectures:45Hours)

3. References

1. Metcalf & Eddy Inc. (2014). Wastewater engineering: Treatment and reuse (5th ed.). Tata McGraw-Hill Education.
2. Benefield, L. D., & Randall, C. W. (2002). Biological process design for wastewater treatment (2nd ed.). Prentice Hall.
3. Qasim, S. R. (2012). Wastewater treatment plants: Planning, design, and operation (3rd ed.). CRC Press.
4. Karia, G. L., & Christian, R. A. (2017). Wastewater treatment: Concepts and design approach (2nd ed.). Prentice Hall.
5. Hendricks, D. (2018). Water treatment unit processes – Physical and chemical (2nd ed.). CRC Press.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	0	2	3	2	2
CO2	2	0	2	3	2	2
CO3	3	0	3	3	2	2
CO4	3	1	3	3	2	3
CO5	3	1	3	3	3	3

CEEN105 ENVIRONMENTAL CHEMISTRY AND MICROBIOLOGY

L	T	P	C
4	0	0	4

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Identify the suitable treatment processes for water and wastewater.
CO2	Explain use of chemistry and microbiology in water and wastewater treatment processes.
CO3	Evaluate the physico-chemical and microbial characteristics of water and wastewater.
CO4	Understand the significance of bio-kinetics and chemical reactions in environmental engineering
CO5	Apply knowledge of chemistry and microbiology for solving various environmental issues.

2. Syllabus

ENVIRONMENTAL CHEMISTRY (30 Hours)

- **BASIC PRINCIPLES (10 Hours)**
  Physical and chemical properties of water and their significance in environmental engineering –Types of chemical reactions – stoichiometric calculations – solutions - chemical equilibrium. Acid-base equilibria – alkalinity, acidity, buffers and buffer index - Chemical thermodynamics – Oxidation–Reduction.
- **TRANSPORT PROCESSES (08 Hours)**
  Mass transfer and transport of impurities in water and air – diffusion, dispersion – Physical and chemical interactions due to various forces, suspensions and dispersions.
- **ANALYSIS (12 Hours)**
  Basic concepts of quantitative analytical chemistry – Instrumental methods of analysis – Significance of turbidity, colour, pH, acidity, alkalinity, hardness, residual chlorine and chlorine demand, chlorides, dissolved oxygen demand, BOD, COD, nitrogen, solids, iron and manganese, fluoride, sulphate, phosphorous and phosphate, grease, volatile acids, gas analysis – Preparation of standard solutions – Drinking water and wastewater standards – Trace organics and inorganics

ENVIRONMENTAL MICROBIOLOGY (30hours)

- **INTRODUCTION (10 Hours)**
  Microorganisms–Classification, prokaryotic and eukaryotic cells, structure, characteristics, nucleic acids, DNA and RNA, Viruses, their detection and quantification–Microscopy–Measurements and Isolation of Microorganism–Different Cultures–Media and Techniques of Staining.
- **MICROBIAL METABOLISM AND GROWTH (10Hours)**
  Enzyme and enzyme kinetics – Metabolism – Respiration – Fermentation – Glycolysis – Kreb's cycle – Carbohydrate – Protein, lipids, significance of energetic – Chemical composition of cell and nature of organic matter used by microorganisms – Metabolic classification of microorganisms: phototrops, chemotrops, applications in environmental engineering.

- **MICROBIOLOGY OF WATER AND WASTEWATER (10Hours)**
  Distribution of microorganisms in natural water – Indicator organisms – Coliforms – Faecal coliforms – *E.coli, Streptococcus faecalis* – Differentiation of coliforms – Significance – MPN – M.F. techniques – Microbiology of wastewater treatment processes such as activated sludge process – Trickling filter – Anaerobic processes. – Introduction to Microbiology of Soil, Air, Marine and Industrial Microbiology – Microbiology of bioremediation and solid waste treatment.

(TotalLectures:60Hours)

3. References

1. Sawyer C.N., McCarty P.L., and Parkin G.F., "Chemistry for Environmental Engineers", Fifth Edition, McGraw Hill, New Delhi, 2017.
2. Benjamin M. M. "Water Chemistry", Second Edition, Waveland Press Inc, 2014.
3. Rittman B., McCarty P.L. and McCarty P., "Environmental Biotechnology: Principles and Applications", McGraw–Hill, New Delhi, 2000.

4. Pelczar Jr, M.J., Chan E.C.S., Krieg R.N., and Pelczar M.F, “Microbiology”, Fifth Edition, Affiliated East West Press, New Delhi, 2023.
5. Maier R.M, Pepper I.L and Gerba C.P., “Environmental Microbiology”, Elsevier-AP, New York 2009.

4. CO-PO-PSO_Mapping

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	2	3	2	2
CO2	1	0	3	3	2	2
CO3	2	1	3	3	2	2
CO4	2	1	3	3	3	3
CO5	3	2	3	3	3	3

CEEN107 ENVIRONMENTAL ENGINEERING LABORATORY

L	T	P	C
0	0	4	2

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understand the sampling methods for water and wastewater.
CO2	Analyze the physico-chemical and biological characteristics of a given sample.
CO3	Select the treatment option based on the sample characteristics.
CO4	Evaluate the impacts of water and wastewater quality on environment.

2. Syllabus

- **CHEMISTRY PRACTICALS** **(30Hours)**

1. Water & wastewater sampling and preservation techniques.
2. Determination of physical characteristics of water and waste water like pH, Turbidity, electrical conductivity, Solids.
3. Determination of Total Hardness, Calcium Hardness, Magnesium Hardness of water sample
4. Determination of Chlorides, Nitrates, Phosphate and Sulphate of water sample.
5. Determination of Residual chlorine of water sample
6. Study of Jar test for different coagulant dose.
7. Determination of DO, BOD and COD of waste water sample
8. Determination of oil and grease of waste water sample
9. Determination of Ammonical Nitrogen, Nitrates and Sulphates of waste water sample
10. Determination of Heavy metals from industrial waste

- **MICROBIOLOGY PRACTICALS** ` **(30 Hours)**

1. Study of Compound and Phase Microscope.
2. Study of staining technique.
3. Study of isolation techniques for bacteria.
4. Determination of Residual chlorine of water sample.
5. Study of MPN test and multiple tube technique.
6. Application of Plate count method for bacterial growth.
7. Effects of pH on growth of bacteria.
8. Effects of Osmotic Pressure on growth of bacteria.

(Total : 60 Hours)

3. References

1. Sawyer, C. N., McCarty, P. L., & Parkin, G. F. (2017). Chemistry for environmental engineers (5th ed.). McGraw-Hill Education.
2. Benefield, L. D., Judkins, J. F., & Weand, B. L. (2014). Process chemistry for water and wastewater treatment (3rd ed.). Prentice Hall.
3. Rittmann, B. E., & McCarty, P. L. (2018). Environmental biotechnology: Principles and applications (3rd ed.). McGraw-Hill Education.
4. De, A. K. (2019). Environmental chemistry (9th ed.). New Age International Ltd.
5. American Public Health Association. (2017). Standard methods for the examination of water and wastewater (23rd ed.). American Public Health Association.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	2	2	3	1	3
CO2	2	3	2	3	2	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3

CEEN109SEMINAR

L	T	P	C
0	**0**	**2**	**1**

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Collect the information on given specific area/topic.
CO2	Update with latest knowledge through exhaustive literature survey
CO3	Collate the information to prepare a report.
CO4	Communicate effectively through skillful presentation.

4. Syllabus:

- Each candidate is required to present one seminar on any chosen topic connected with the field of specialization. The topic shall be chosen in consultation with the concerned faculty. Preparation and Presentation of a seminar is intended to investigate an in–depth review of literature; to prepare a critical review and to develop confidence for making a good presentation. Assessment is based on the presentation and contents of the seminar report prepared. A report has to be submitted in the prescribed format and seminar shall be evaluated by the respective department committee.
- Expert Lectures can be arranged from various Environmental Consultants so that can student can get the exposure to field related problem

5. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	1	1	2	3
CO2	3	3	1	1	2	3
CO3	2	3	1	1	2	2
CO4	1	3	1	1	2	2

ELECTIVE – 1

CEEN111 ENVIRONMENTAL LEGISLATION AND IMPACT ASSESSMENT

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Interpret and explain the objectives and scope of EIA.
CO2	Categorize the importance of environmental attributes.
CO3	Describe the legal provisions and statutory requirement of environmental clearance.
CO4	Calculate the identification and prediction of environmental impacts of new/expansion projects.
CO5	Formulate an EIA for any given project.

2. Syllabus

- **IMPACT ASSESSMENT: TYPES AND SIGNIFICANCE** **(03 Hours)**
  Types of impacts, significant impacts, various impact assessments viz. health impact assessment, social impact assessment, disaster impact assessment, strategic environmental assessment.

- **EIA: INTRODUCTION & PLANNING** **(06 Hours)**
  Evolution of EIA; EIA at project; regional and policy levels; EIA legislative and environmental clearance procedures in India; EIA Rules-1994 and subsequent amendments, Rapid and Comprehensive EIA.

- **EIA: METHODOLOGIES AND STRATEGIES** **(14 Hours)**
  Screening, baseline data collection, environmental inventory of physical, biological and socio-economic environment attributes, terms of reference, scoping, identification of impacts, rapid and comprehensiveEIA, monitoring, analysis and report preparation in EIA, impact prediction tools / techniques such as adhocmethod, checklist method, development of environment management plan, post project monitoring.

- **PUBLIC PARTICIPATION** **(03 Hours)**
  Project Affected Persons, significance of public participation in EIA, methods of public consultation – Public Notice and Public Hearing, Resettlement and rehabilitation issues, Land Acquisition, Rehabilitation and Resettlement Act, 2013.

- **EIA CASE STUDIES** **(10 Hours)**
  Case studies / histories for different types of projects like metro rail project, nuclear power project, large hydro-electric power project, pharmaceutical industry, township and area development projects.

- **NATIONAL ACTS & RULES FOR ENVIRONMENTAL PROTECTION** **(09 Hours)**
  Indian environmental legislation and acts such as Water Act-1974, Air Act-1981, Wildlife Protection Act-1972, Forest Conservation Act-1980, Public Liability Insurance Act 1991, Environment Protection Act (EPA) – 1986; Various Rules under EPA-1986 such as Biomedical Waste Rules-~~1998~~ 2016, Coastal Regulation Zone-1999, Municipal Solid Waste rules, Hazardous Waste Rules-2016, Noise Regulation & Control Rules-2000, National Green Tribunal, NGT Act-2010, Case studies of landmark judgements given by NGT and various Courts.

(Total Lectures: 45Hours)

3. References

1. Canter, L. W. (2018). Environmental impact assessment (3rd ed.). Tata McGraw-Hill Education.

2. Munn, R. E. (2018). Environmental impact assessment (2nd ed.). John Wiley & Sons.
3. Dhameja, S. K. (2014). Environmental engineering and management (2nd ed.). S. K. Kataria & Sons.
4. Central Pollution Control Board (CPCB). (n.d.). General standards. Retrieved from https://cpcb.nic.in/general-standards/
5. Ministry of Environment, Forest and Climate Change (MoEF&CC). (n.d.). Rules and regulations: Environment protection. Retrieved from https://moef.gov.in/en/rules-and-regulations/environment-protection/
6. Central Pollution Control Board (CPCB). (n.d.). Home page. Retrieved from https://cpcb.nic.in/index.php

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	1	2	2	1	3
CO2	2	3	2	2	1	2
CO3	1	3	1	1	1	1
CO4	3	1	3	3	2	3
CO5	3	3	3	3	3	3

ELECTIVE – 1

CEEN113 ENVIRONMENTAL HYDRAULICS

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understand the concepts of fluid flow analysis.
CO2	Compare different methods of network analysis.
CO3	Analyze water distribution system network with various tools and techniques.
CO4	Design storm water and sewerage network system.
CO5	Develop the hydraulic flow diagram for a treatment plant.

2. Syllabus

- **FUNDAMENTALS** **(06 Hours)**

  Basic equations for fluid flow analyses including Reynolds transport theorem – Basic concepts of flow through pipes.

- **WATER DISTRIBUTION SYSTEM DESIGN** **(10 Hours)**

  General design requirements – Methods of analyses – Control of water hammer in long distance transmission. – Introduction to optimization of water distribution system.

- **URBAN STORM DRAINAGE DESIGN** **(11 Hours)**

  Introduction to drainage problems in difficult climates. – Planning concepts, Rainfall intensity-duration – Frequency curves. – Design of drainage system elements, – Control of storm water pollution.

- **SEWERAGE SYSTEM AND SEWAGE TREATMENT PLANT DESIGN** **(10 Hours)**

  General design principles of sewers, Recent Development in sewerage system design – Application of softwares **-** Hydraulic design of STP- CETP design

- **GROUND WATER MANAGEMENT** **(08 Hours)**

  Well development – Artificial recharge – Salinity of ground water – Ground water pollution – Infiltration gallery – Central Ground Water Authority guidelines, 2015 -

(Total Lectures: 45Hours)

3. References

1. Chow, V. T. (2020). Open-channel hydraulics (3rd ed.). McGraw-Hill Education. (Original work published 1959)
2. Ranga Raju, K. G. (2017). Flow through open channels (3rd ed.). Tata McGraw-Hill Education.
3. Bhave, P. R., & Gupta, R. (2020). Analysis of water distribution networks (3rd ed.). Alpha Scientific.
4. Bear, J. (2021). Hydraulics of groundwater (3rd ed.). McGraw-Hill Education.
5. Central Public Health and Environmental Engineering Organisation (CPHEEO). (2023). Water supply and treatment manuals (3rd ed.). CPHEEO.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	0	3	1	2	2
CO2	2	0	3	2	2	2
CO3	2	0	3	2	2	3
CO4	2	1	3	3	2	3
CO5	2	2	3	3	3	3

ELECTIVE – 1

CEEN115 GIS AND REMOTE SENSING IN ENVIRONMENTAL ENGINEERING

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understand the Remote Sensing and GIS system for different data types.
CO2	Execute different techniques of image interpretation and processing.
CO3	Create different types of thematic maps.
CO4	Apply various spatial data analysis techniques.
CO5	Analyze and solve complex environmental engineering problems using GIS and Remote Sensing.

2. Syllabus

- **INTRODUCTION** **(05 Hours)**

  Introduction to GIS and Remote Sensing – Usefulness in Environmental Engineering

- **GEOGRAPHIC INFORMATION SYSTEM** **(10 Hours)**

  Components of GIS – GIS Data – Georeferenced data – Data input and output – Data Models – DBMS

- **FUNDAMENTAL OF REMOTE SENSING** **(10 Hours)**

  Definition – Components of Remote Sensing – Principles of Remote Sensing Energy Sources – Active and Passive Remote Sensing – Electro Magnetic Radiation (EMR) and the Electromagnetic Spectrum – Interaction of EMR with the Earth's Surface – Interactions with the Atmosphere

- **IMAGE INTERPRETATION AND DIGITAL IMAGE PROCESSING** **(10 Hours)**

  Interpretation Procedure – Strategies – Keys – Equipments – Digital Image Processing – Rectification and Restoration

- **GEOSPATIAL ANALYSIS AND APPLICATIONS** **(10 Hours)**

  GIS and image interpretation software – Salient features – Capabilities and Limitations - Methods - Measurements - Analysis – GEO visualization, application of Remote Sensing / GIS in Environmental Engineering – Case studies – Integration of GIS and Remote Sensing – Management and Monitoring of land, air, water pollution – conservation of resources and coastal zone management – Landuse planning.

(Total Lectures: 45Hours)

3. References

1. Lillesand, T. M., & Kiefer, R. W. (2020). Remote sensing and image interpretation (8th ed.). John Wiley & Sons.
2. Burrough, P. A., & McDonnell, R. A. (2015). Principles of geographic information systems (4th ed.). Oxford University Press.
3. Chandra, A. M., & Ghosh, S. K. (2016). Remote sensing and geographical information system (2nd ed.). Narosa Publishing House.
4. Bhatta, B. (2019). Remote sensing and GIS (2nd ed.). Oxford University Press.
5. Aronoff, S. (2016). Geographical information systems (3rd ed.). WDL Publications.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	1	2	1	2	1
CO2	1	1	2	2	2	2
CO3	1	2	2	2	2	2
CO4	2	1	2	3	2	3
CO5	3	2	3	3	3	3

ELECTIVE – 2

CEEN117SUSTAINABLE WASTE MANAGEMENT SYSTEM

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Introduce the concept of sustainability.
CO2	Understand the ecological and natural treatment systems.
CO3	Understand the concept and design of water conservation techniques.
CO4	Design of natural and decentralized treatment systems.
CO5	Design of various systems for waste management.

2. Syllabus

- **INTRODUCTION** **(06 Hours)**

  Concept of sustainability in water and waste management – Ecology, relationship between ecology, environment and waste management - Environmental indices- Bio remediation

- **WATER CONSERVATION AND REUSE** **(12 Hours)**

  Rainwater Harvesting – Roof water harvesting – Technology – Quality – Health issues –Groundwater recharge – Techniques – Greywater – Zero Liquid Discharge - Case studies – Wastewater reuse and reclamation.

- **NATURAL WASTEWATER TREATMENT SYSTEMS** **(10 Hours)**

  Centralized Vs decentralized – Natural and constructed wetlands – Different types – Mechanisms – Performance – Design – Case studies – Land treatment systems.

- **LOW–COST SANITATION** **(08 Hours)**

  Dry sanitation methods – Pit latrines – VIP latrines – Aquaprivy – Septic tank- Waterless urinals

- **SOLID WASTE MANAGEMENT TECHNIQUES** **(09 Hours)**

  Composting/vermicomposting – Liquid fertilizer – Biogas technology – Waste to Energy Technologies - Plasma technology.

(Total Lectures: 45Hours)

3. References

1. Crites, R. W., Middlebrooks, E. J., & Reed, S. C. (2020). Natural wastewater treatment systems (3rd ed.). CRC Press.
2. Cairncross, S., & Feachem, R. (2021). Environmental health engineering in the tropics (2nd ed.). John Wiley & Sons.
3. White, I. D., Mottershead, D. N., & Harrison, S. L. (2006). Environmental systems: An introductory text (2nd ed.). Chapman and Hall.
4. Tchobanoglous, G. (2014). Solid wastes: Engineering principles and management issues (2nd ed.). McGraw-Hill Education.
5. Martin, A. M. (2014). Biological degradation of wastes (2nd ed.). Elsevier.

4. CO-PO-PSO_Mapping

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	1	1	1	1
CO2	3	1	1	1	2	1
CO3	3	1	2	1	2	2
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3

ELECTIVE – 2

CEEN119 OCCUPATIONAL HEALTH, SAFETY & ENVIRONMENT

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Identify and explicate the inter-relationship of industries and the government in context to occupational health, environment and safety.
CO2	Understand the statutory requirement of safety and environmental legislation.
CO3	Apply theories and concepts of occupational health and safety for workplace environment.
CO4	Develop and implement safe operating procedures (SOPs) for various industrial activities.
CO5	Execute Health Safety Environment (HSE) policy and Environmental Management Systems.

2. Syllabus

- **INTRODUCTION** **(05 Hours)**
  Safety – Safety and Productivity – Role of Government – National Safety Council – National Safety Awards – Housekeeping – Significance of occupation health in industries – Industries and environment protection.

- **OCCUPATIONAL ENVIRONMENT – BASICS & STANDARDS** **(12 Hours)**
  Working environment TYPES – Health impacts in an occupational environment – Effects of environmental factors on human body & mind – Basics of environment design - Improved efficiency and accuracy at work. ISO 14000 introduction – General description of ISO 14001 – Environment Management System (EMS) – Key elements of ISO 14001 and EMS.

- **SAFETY – PLANNING, STANDARDS AND LEGISLATION** **(11 Hours)**
  Safety Standards – HAZOP studies - ILO Model code of safety regulation / legislation – Risk Analysis – Risk Assessment – Indian Factories Act – Boiler Act – Electricity Act – Workman's compensation act - Purpose for planning – planning procedure – Range of plans – Safety policies – Elements and implementation of safety policy – ~~Implementation~~ – Disaster Management – On-site & Off-site emergency plan.

- **OCCUPATIONAL ERGONOMICS** **(07 Hours)**
  Ergonomics – Human-body – Health – Posture – Workplace or office ergonomics – Ergonomics for women at work – physical work and environment – Anthropometry

- **OCCUPATIONAL STRESS AND HEATH** **(10 Hours)**
  Work related stress – Causes of stress – Signs of stress – Measurement of stress – Stress management systems – Prevention – Stress health and productivity – Occupational safety and health Act – Health program – First Aid

(Total Lectures: 45Hours)

3. References

1. Jain, R. K., & Rao, S. S. (2020). Industrial safety, health, and environment management systems (2nd ed.). Khanna Publishers.
2. Parashar, P., & Bansal, P. (2018). Industrial safety and environment (2nd ed.). S.K. Kataria & Sons.
3. Agrawal, S. K. (2012). Industrial environment assessment and strategy (2nd ed.). APH Publishing Corporation.
4. Slote, L. (2017). Handbook of occupational safety and health (3rd ed.). John Wiley & Sons.

5. National Safety Council. (2015). Safety, health, and working conditions: Training manual (2nd ed.). National Safety Council.

4. CO-PO-PSO_Mapping

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	2	2	1	3
CO2	2	3	2	2	1	2
CO3	1	3	1	1	1	1
CO4	3	1	3	3	2	3
CO5	3	3	3	3	3	3

ELECTIVE – 2

CEEN121ADVANCED WATER AND WASTEWATER TREATMENT

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Design advanced treatment systems for water treayment
CO2	Design advanced systems for w**astewater treatment**
CO3	Design sludge treatment and disposal systems
CO4	Design various systems for nutrient removal and recovery
CO5	Design units for wastewater reuse

2. Syllabus

- **ADVANCED WATER/WASTEWATER TREATMENT PROCESSES (25 Hours)**

Membrane processes– Desalination – Reverse Osmosis, Electro-dialysis, Ceramic filters, Ion–exchange – Aeration/gas transfer – Precipitation – oxidation-reduction processes – Adsorption, heavy metal removal, evaporators

Advanced oxidation processes – Bio-electro systems - Air stripping

Advanced biological processes - modification of activated sludge process- modelling of biological wastewater treatment systems – Nutrient removal and recovery processes - Design of disposal systems

- **SLUDGE TREATMENT AND DISPOSAL (12 Hours)**

Comparison of different sludge treatment systems – disposal of sludge – advantages and disadvantages – sludge reuse

- **WATER REUSE (8 Hours)**

Need for wastewater reuse, greywater reuse, different uses - standards, processes for treatment - risks assessment

(Total Lectures: 45Hours)

3. References

1. Qasim, S. R., Motley, E. M., & Zhu, G. (2017). Water works engineering (2nd ed.). Prentice-Hall India.
2. Montgomery, J. (2021). Water treatment principles and design (3rd ed.). John Wiley & Sons.
3. Metcalf & Eddy. (2014). Wastewater engineering: Treatment and reuse (5th ed.). Tata McGraw-Hill.
4. Central Public Health and Environmental Engineering Organisation (CPHEEO). (2012). Manual on water supply and treatment. Ministry of Urban Development, Government of India.
5. Central Public Health and Environmental Engineering Organisation (CPHEEO). (2005). Manual on sewerage and sewage treatment. Ministry of Urban Development, Government of India.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	3	3	2	2
CO2	2	1	3	3	2	2
CO3	2	1	3	3	3	3
CO4	2	1	3	3	3	3
CO5	2	1	3	3	3	3

Second Semester

CEEN102SOLID AND HAZARDOUS WASTE MANAGEMENT

L	T	P	C
3	1	0	4

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Introduce solid and hazardous waste management issues and its legal aspects
CO2	Characterize and quantify solid and hazardous waste..
CO3	Design collection, transportation and processing of waste management system.
CO4	Design disposal and treatment facility for solid and Hazardous waste
CO5	Develop waste management facility for bio medical, plastic ,E-waste, construction waste etc.

2. Syllabus

- **INTRODUCTION** **(06 Hours)**

  Solid waste sources – Nature and characteristics – Quantities and Qualities – Generation rates – Potential of disease – Nuisance and other problems – Solid Waste Management Rules, 2016 and amendments, Characterization and composition of hazardous waste, Hazardous and other wastes (Management & Transboundary Movement) Rules – 2016.

- **COLLECTION, STORAGE AND TRANSPORT OF SOLID WASTE** **(10 Hours)**

  Solid waste management – Functional elements of solid waste–on–site storage –Collection and separation – Containers and its location – Collection systems and its example – physical, chemical and microbiological characteristics of waste – Vehicle routing – Route balance – Transfer station – Processing – Recovery and reuse.

- **PROCESSING OF SOLID WASTE** **(11 Hours)**

  Conveying and compacting waste – Shredding – Types of shredders – Shredders Design–Material separation – Types – Devices for material separation – Thermal processing of municipal solid waste – incinerator and pyrolysis – Refuse Derived fuel – Biological process like composting, vermi-composting and bio-methanation, City compost plant, Waste to Energy plant.

- **DISPOSAL OF SOLID WASTE** **(06 Hours)**

  Disposal methods – Sanitary land filling – Planning – Site selection – Design – Landfill Process – Monitoring Closure – Post closure monitoring – Other methods like incineration, pyrolysis, and composting, biological digestion.

- **INDUSTRIAL HAZARDOUS WASTE MANAGEMENT** **(06 Hours)**

  Introduction to hazardous waste – Definition – TCLP test – Storage and transportation of hazardous waste – Labeling of hazardous waste – Physical, Chemical and Biological treatment of hazardous waste – Bioremediation of hazardous waste – Treatment of Bio medical – Nuclear waste and Radio – Active waste – Fly ash management and E-waste management.

- **SPECIALIZED WASTE MANAGEMENT** **(06 Hours)**

  Construction & demolition waste management - Plastic waste management - Bio-medical waste management – Radioactive waste – Fly ash management – e-Waste management – Cement co-processing – Circular economy.

(Total Lectures: 45Hours)

3. References

1. Rimbers, D. (2016). *Municipal solid waste management: Pollution technologies review* (2nd ed.). Noyes Data Corporation.
2. Wentz, C. A. (2019). *Hazardous waste management* (4th ed.). McGraw-Hill Education.

3. Tchobanoglous, G. (2014). *Solid wastes: Engineering principles and management issues* (2nd ed.). McGraw-Hill Education.
4. LaGrega, M. D., Buckingham, P. L., & Evans, J. C. (2010). *Hazardous waste management* (2nd ed.). McGraw-Hill Education.
5. Central Public Health and Environmental Engineering Organisation (CPHEEO). (2016). *Solid waste management: CPHEEO manual*. CPHEEO.

4. CO-PO-PSO_Mapping

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	2	1	2	2
CO2	2	1	2	1	2	2
CO3	2	2	3	2	3	3
CO4	2	2	3	2	3	3
CO5	2	2	3	3	3	3

CEEN104 AIR POLLUTION AND CONTROL

L	T	P	C
3	1	0	4

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Identify the air pollutants sources and understand their fate and transport under various meteorological conditions.
CO2	Demonstrate the understanding of basic science of air pollutants propagation and meteorology.
CO3	Analyze the effects and impacts arising from air pollutants.
CO4	Simulate air pollution concentrations using various mathematical, numerical models and softwares.
CO5	Design and apply pollution control devices for different environmental conditions.

2. Syllabus

- **AIR POLLUTION: BASICS AND STANDARDS** **(06 Hours)**

  Air Pollution – Definition – Sources and classification – Air Pollutants: Effects on human health, vegetation, materials and atmosphere –Ambient air quality monitoring and stack emission sampling – Principles of various instruments used in air quality monitoring – Sensor based analysers.

- **AIR QUALITY INDEX AND STANDARDS** **(08 Hours)**

  Source apportionment and emission inventory – Smoke, ozone layer, smog, haze and visibility – Air Quality Index (AQI)– SAFAR - Air quality standards and legislation.

- **METEOROLOGY AND DIFFUSION/DISPERSION MODELS** **(15 Hours)**

  Introduction to air pollution meteorology – Atmospheric motion – Lapse rates – Atmospheric stability – Inversions and its effects on pollutants – Atmospheric diffusion of pollutants – Transport – Transformation and deposition of air contaminants – Removal processes– Maximum Mixing Depths – Plume rise – Types of dispersion models like Gaussian Plume, Box, Line, Area.

- **AIR POLLUTION CONTROL TECHNOLOGIES: PARTICULATES** **(10 Hours)**

  Settling chambers, cyclone separation – Wet collectors – Fabric filters, electrostatic precipitators and other removal methods like absorption – Adsorption and precipitation.

- **AIR POLLUTION CONTROL TECHNOLOGIES: GASEOUS POLLUTANTS** **(06 Hours)**

  Removal of gaseous pollutants by adsorption, absorption, reactions and other methods.

(Total Lectures: 45Hours)

3. References

1. Wark, K., & Warner, C. F. (2022). Air pollution: Its origin and control (4th ed.). Harper & Row Publishers.
2. Rao, C. S. (2020). Environmental pollution control engineering (3rd ed.). New Age International Ltd.
3. De Nevers, H. (2018). Air pollution control engineering (3rd ed.). McGraw-Hill Education.
4. Griffin, R. D. (2019). Principles of air quality management (2nd ed.). CRC Press.
5. Boubel, R. W. (2017). Fundamentals of air pollution (5th ed.). Academic Press.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	1	2	1	2	2
CO2	2	1	2	2	2	2
CO3	2	2	3	3	3	3
CO4	2	2	3	3	3	3
CO5	3	3	3	3	3	3

CEEN106 ADVANCED ENVIRONMENTAL ENGINEERING LABORATORY	**L**	**T**	**P**	**C**
	0	**0**	**4**	**2**

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Identify suitable treatment processes for a given water and wastewater.
CO2	Apply physico-chemical and biological processes for water and wastewater treatment.
CO3	Characterize municipal solid wastes.
CO4	Determine air pollutants concentration in ambient air.
CO5	Determine first order and second order kinetics.

2. Syllabus

Practicals:

1. Determination of coagulant dosage.
2. Determination of BOD rate constant
3. Filtration Performance Studies
4. Adsorption kinetics and equilibrium
5. Settling characteristics of solids
6. Removal of heavy metals by precipitation
7. pH Buffers and Buffering capacity
8. Study of Wastewater Disinfection
9. Study of Water Softening Process
10. Aeration and Coefficient of Aeration
11. Study of Activated Sludge Process
12. Analysis of solid wastes – Proximate and ultimate analysis
13. Characterization of wastes from different industries
14. Demonstration of Stack monitoring kit.
15. Analysis and calculation of particulate matter, SO_2 and NO_X for ambient air quality.
16. Demonstration and application of sound level meter

(Total : 60Hours)

3. References

1. Sawyer C.N., McCarty P.L., and Parkin G.F., "Chemistry for Environmental Engineers", 4th Edn. McGraw Hill, New Delhi, 1994.
2. Benefield, Judkins and Weand, "Process Chemistry for Water and Wastewater Treatment", 2nd edition Prentice Hall,New Delhi,1980.
3. Rittman B., McCarty P.L. and McCarty P., "Environmental Biotechnology: Principles and Applications", 2nd edition, McGraw–Hill, 2000.
4. De. A.K., "Environmental Chemistry", New Age International Ltd., New Delhi, 1995.
5. "Standards Methods for the Examination of Water & Waste water", 21st Edition, American

   Public health Association, Washington. D.C. 2005.

CEENXXXMINI PROJECT

L	T	P	C
0	**0**	**0**	**2**

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Inculcate the culture of working in group
CO2	Identify a field problem related to environmental issues.
CO3	Compare different methods/solutions through literature review/experiments.
CO4	Design and implement optimum/sustainable solution.

- Students in consultation with the faculty advisor will decide a specific problem and are required to study and analyse the assigned problem**.** They are required to submit a project report at the end**.** The faculty adviser and the department committee will internally assess project**.**

2. CO-PO-PSO_Mapping

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	**1**	**1**	**0**	**0**	**3**	**2**
CO2	2	1	2	2	3	2
CO3	2	3	2	2	3	3
CO4	2	3	3	2	3	3

CEEN302 INDUSTRIAL TRAINING

L	T	P	C
0	0	0	2

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Conduct onsite industrial visit for comprehensive field exposure.
CO2	Obtain practical knowhow about processes, emissions and discharges.
CO3	Understand the work culture and environment of industry.
CO4	Identify the environmental engineering problems related to industry.

- The intention of summer training is to develop the effective skills of the student and to expose them with actual problems faced in the industry. The students have to undergo the summer training during the period of summer vacation after completion of first year. The minimum duration of training is at least 6 weeks.

- Students will identify a suitable industry / consultant firm in consultation with the faculty advisor and study the relevant environmental issues. The student has to submit a training report, with duly signed certificate of the industry / consultant firm, where the training/practical/experimental work has been carried out. The evaluation of the report will be carried out by the department level committee.

2.CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	2	0	1	1
CO2	3	1	3	2	2	2
CO3	3	2	3	1	3	3
CO4	3	2	3	3	3	3

ELECTIVE – 3

CEEN112 INDUSTRIAL WASTE MANAGEMENT

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Explain the sources of industrial pollutants and its impact on environment
CO2	Classify the pollutants for various industry
CO3	Develop plan and strategies using tools and techniques for prevention of pollution in industrial area.
CO4	Select advance control technology for waste minimization programme.
CO5	Develop / formulate Waste Control strategies to minimise industrial pollution.

2. Syllabus

- **INTRODUCTION** **(10 Hours)**

  Sources of wastes – Industrial and domestic – Nature and characteristics of wastewater – Industrial wastewater and environmental impacts – Regulatory requirements for treatment of industrial wastewater– Quality and quantity of industrial wastes –Evaluation of pollution prevention – physical, chemical and biological process. Prevention vs Control of Industrial Pollution – Benefits and Barriers – Decommissioning of industrial projects.

- **INDUSTRIAL POLLUTION PREVENTION** **(10 Hours)**

  Waste minimization – Source reduction Techniques – waste volume reduction - Waste strength reduction – Neutralization – Removal of suspended and colloidal solids – Removal of inorganic and dissolved solids – reduction of wastewater at point source.

- **ADVANCE WASTEWATER MANAGEMENT** **(12 Hours)**

  Waste Audit – Mass Balance - Toxicity of industrial effluents and Bioassay tests - Individual and common effluent treatment plants – Zero liquid discharge (ZLD) systems – Multiple Effect Evaporator (MEE), Advanced Oxidation, Wet Air Oxidation, Wastewater quality requirements for its reuse. Quantification and characteristics of Sludge – Thickening, conditioning, digestion, dewatering and sludge disposal

- **CASE STUDIES** **(13 Hours)**

  Industrial manufacturing process description – source of wastewater –Wastewater characterization - effect of wastewater on receiving water and sewers –waste treatment flow sheet for Textiles, Tanneries, Pulp and paper, Pharmaceuticals, Sugar, Steel, Fertilizer, Oil and Petrochemicals, Cement.

(Total Lectures: 45Hours)

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3. References

1. Smith, P. G., & Scott, J. S. (2022). *Dictionary of water and waste management*. Heinemann.
2. Barton, S. N. (2023). *Industrial waste: Management, assessment, and environmental issues* (2nd ed.). Nova Science Publishers.

3. Patwardhan, A. D. (2019). *Industrial wastewater treatment* (2nd ed.). PHI Learning.
4. Nemerow, N. L. (2018). *Industrial waste treatment* (3rd ed.). Elsevier Butterworth-Heinemann.
5. Rao, M. N., & Datta, A. K. (2022). *Wastewater treatment* (3rd ed.). Oxford & IBH Publishing.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	1	2	1	2	2
CO2	1	2	2	1	2	2
CO3	2	3	3	2	3	3
CO4	2	3	3	3	3	3
CO5	2	3	3	3	3	3

ELECTIVE – 3

CEEN114 ENVIRONMENTAL SYSTEM MODELLING

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understand mathematical models with system definition and components.
CO2	Identify types of models and their applications
CO3	Select appropriate models for diffusion and dispersion of pollutants.
CO4	Develop simple models for transport and fate of different contaminants
CO5	Apply different soft computing techniques in environmental engineering.

2. Syllabus

- **INTRODUCTION (8 Hours)**

  Mathematical modelling and simulation – Defining systems and its components – Types of models and their applications – Evaluation of models – Graphical analysis – Quantitative analysis – Sensitivity analysis – Uncertainty analysis.

- **TRANSPORT AND FATE OF CONTAMINANTS- FUNDAMENTALS (10 Hours)**

  Mass and energy balance – Advection – Molecular diffusion and dispersion – Chemical transformations - sorption/desorption - Photochemical transformations and Biological transformations.

- **TRANSPORT AND FATE OF CONTAMINANTS - MODEL APPICATIONS (16 Hours)**

  Modelling approaches - Modelling of rivers-lakes, sediments, wetlands, subsurface flow and transport – Water dispersion models - Air pollution modelling - Modelling of volatilization, Models for activated sludge process – Anaerobic processes.

- **INTRODUCTION TO SOFT COMPUTING TECHNIQUES (11 Hours)**

  MCDM techniques - Analytic hierarchy process –Fuzzy set theory - Neural networks - Applications in environmental engineering.

(Total Lectures: 45Hours)

3. References

1. Ramaswami A., Milford J.B., Small M.J., "Integrated Environmental Modeling – Pollutant Transport, Fate, and Risk in the Environment", John Wiley & Sons, 2005.
2. NirmalaKhandan, "Modeling Tools for Environmental Engineers and Scientists", CRC Press, 2020.
3. Snape J.B., Dunn I.J., Ingham J. and Prenosil J., "Dynamics of Environmental Bioprocesses, Modelling and Simulation", Weinheim: VCH, 1995.
4. International Water Association, "Activated sludge modelling", ASM1 and ASM2
5. Chapra S.C., "Surface Water Quality Modeling", McGraw–Hil, Inc., New York, 1997.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	0	3	2	1	2
CO2	2	0	3	2	2	2
CO3	3	2	3	2	2	3
CO4	3	2	3	2	3	3
CO5	3	2	3	3	3	3

ELECTIVE – 3

CEEN116WASTE-TO-ENERGY TECHNOLOGIES

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Identify waste characteristics with respect to waste- to-energy technologies.
CO2	Compare different waste-to-energy technologies with respect to its applicability.
CO3	Evaluate waste-to-energy technologies with respect to sustainability perspective.
CO4	Design biological waste-to-energy systems.
CO5	Design thermal waste-to-energy systems.

2. Syllabus

- **CHARACTERIZATION OF SOLID WASTES (10 hours)**
  Wastes and their classification, Important quality parameters, Wastes suitable for energy production, Municipal solid wastes and their availability in India, Characterisation of solid wastes, proximate and ultimate analysis, leaching properties, Energy content and heating value – Energy balance
- **INCINERATION AND GASIFICATION (13 hours)**
  Incineration scope and application, Mechanism, air requirements, Performance factors, Feedstock characteristics, Incinerator working, Environmental impacts and issues, Basics of gasification, gasification products, syngas, gasifier types, Gasifiers for biomass and wastes, Comparison between incineration and gasification, Syngas utilization
- **PYROLYSIS, GAS PURIFICATION (09 hours)**
  Mechanism, types, operating conditions, end products, properties of bio-oil, Densification of solids, efficiency improvement of power plant and energy production from waste plastics. Properties of gas produced through different routes, Gas clean up, removal of particulates
- **ANAEROBIC PROCESSES (09 hours)**
  Anaerobic processes fundamentals, microbiology, pathways, pre-treatment, types and operation of anaerobic digester, Design of anaerobic digesters, Introduction to microbial fuel cells. Energy production from wastes through fermentation
- **ALGAL BIOMASS AND ENERGY PRODUCTION (04 hours)**
  Characteristics of algal biomass, Cultivation and growth of algae, Reactor systems and harvesting, Bio fuel production from algal biomass, Conversion processes, Factors affecting yield, homogeneous and heterogeneous catalyst.

(Total Lectures: 45Hours)

3. References

1. Rogoff, M. J., & Screve, F. (2024). Waste-to-energy: Technologies and project implementation (2nd ed.). Elsevier.
2. Young, G. C. (2019). Municipal solid waste to energy conversion processes (2nd ed.). John Wiley & Sons.
3. Harker, J. H., & Backhurst, J. R. (2019). Fuel and energy (2nd ed.). Academic Press.
4. Peavy, H. S., Rowe, D. R., & Tchobanoglous, G. (2018). Environmental engineering (2nd ed.). McGraw-Hill Education.
5. Tchobanoglous, G., & Kreith, F. (2014). Handbook of solid waste management (2nd ed.). McGraw-Hill Education.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	1	2	1	2	2
CO2	2	1	2	1	2	2
CO3	2	2	3	2	3	3
CO4	2	2	3	2	3	3
CO5	2	2	3	3	3	3

CEEN118NOISE, INDOOR AIR AND ODOURPOLLUTION

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Interpret the legal provisions and statutory requirements of noise, air and odour pollution.
CO2	Demonstrate the understanding of basic science of noise and indoor air propagation.
CO3	Analyze the effects and impacts arising from noise, indoor air and odour pollution.
CO4	Compare and select methods of improving indoor environmental quality systems.
CO5	Design of noise maps and mitigation measures using mathematical models and softwares.

2. Syllabus

- **INDOOR AIR POLLUTION: BASICS** **(03 Hours)**

  Indoor air quality, indoor air pollution sources, health effects of various indoor air pollutants, household pollutants, principles & types of ventilation, various types of air conditioning systems. Instruments for indoor air quality parameters like PM_{10}, $PM_{2.5}$, CO_2, VOCs, Bio-aerosols.

- **INDOOR AIR POLLUTION: IMPACTS & CONTROL TECHNIQUES** **(06 Hours)**

  Impact of aerosol properties on indoorair quality, construction materials and indoor air quality, impact of PM_{10}, $PM_{2.5}$, Formaldehyde, Carbon Monoxide, VOCs on human health, Sick Building Syndrome, strategies for indoor air pollution control.

- **SOUND AND NOISE: BASICSAND LEGISLATION** **(08 Hours)**

  Sound, noise, physiology of hearing, frequency, wavelength, speed,loudness of sound, sound pressure and sound pressure level, equivalent noise level, noise indices, frequency and octave bands, A and C weighted frequencies, charts for addition and subtraction of sound pressure levels, Noise Pollution (Regulation and Control) Rules 2000.

- **NOISE POLLUTION: SOURCES & IMPACTS** **(10 Hours)**

  Noise pollution sources, effects of noise pollution, auditory and non-auditory effects, calculation of hearing handicap, CPCB ambient noise standards, OSHA noise standards for work place, WHO hearing loss standards.

- **NOISE CONTROL TECHNIQUES AND MODELLING** **(12 Hours)**

  Mitigation of noise at source - use of PPEs - noise barrier design - use of softwares' like SOUNDPLAN, CADNA, LIMA – application of mathematical noise prediction models like FHWA, CoRTN, RLS-90 - use of neuro-fuzzy, genetic algorithm optimization, neural networks in noise modelling.

- **ODOUR POLLUTION** **(06 Hours)**

  Chemicals and processes responsible, elements of odour, odour threshold and character, strategies for odour pollution control.

(Total Lectures: 45Hours)

3. References

1. Wang, L. K., Pereira, N. C., & Hung, Y. (2022). *Advanced air and noise pollution control* (2nd ed.). Humana Press.
2. Bugliarello, G., Alexander, A., Barnes, J., & Wakstein, C. (2020). *The impact of noise pollution: A socio-technological introduction* (2nd ed.). Pergamon Press Inc.
3. Central Pollution Control Board (CPCB). (2020). *Manual on guidelines on odour pollution and its control*. CPCB.
4. Central Pollution Control Board (CPCB). (n.d.). *Home page*. Retrieved from https://cpcb.nic.in/index.php

5. Ministry of Environment, Forest and Climate Change (MoEF&CC). (n.d.). *Rules and regulations: Environment protection*. Retrieved from https://moef.gov.in/en/rules-and-regulations/environment-protection/
6. Central Pollution Control Board (CPCB). (n.d.). *General standards*. Retrieved from https://cpcb.nic.in/general-standards/

4. CO-PO-PSO_Mapping

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	2	1	2	2
CO2	2	1	2	1	2	2
CO3	2	2	3	2	3	3
CO4	2	2	3	2	3	3
CO5	2	2	3	3	3	3

ELECTIVE – 4

CEEN120 APPLIED STATISTICS FOR ENGINEERS

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Analyze and interpret engineering data.
CO2	Apply different sampling distributions to engineering data.
CO3	Use hypothesis testing for various cases.
CO4	Develop simple linear regression models and correlation.
CO5	Design statistical experiments.

2. Syllabus

- **INTRODUCTION** **(07 Hours)**

  Graphical presentation of data: dot and scatter plots – Frequency distribution and histogram – Box plot and time plots – Numerical distribution of data: Measures of Central tendency – Dispersion – Skewness and kurtosis – Measuring association – Grouped data.

- **SAMPLING DISTRIBUTIONS** **(10 Hours)**

  Random variables and expectation – Discrete and continuous random variables – Sampling distributions – Important discrete distributions – Binomial – Poisson and geometric distributions – Normal distribution – Central limit theorem.

- **PARAMETER ESTIMATION** **(06 Hours)**

  Point estimation – Confidence interval estimation.

- **TESTS OF HYPOTHESIS** **(08 Hours)**

  Tests of hypothesis on single sample and two samples – Goodness of fit – Tests based on Normal – t – Chi–square – F distributions.

- **SIMPLE LINEAR REGRESSION AND CORRELATION** **(06 Hours)**

  One way and two way classification.

- **DESIGN OF EXPERIMENTS** **(08 Hours)**

  Completely randomized single factor experiment – Analysis of variance – Randomized block design – Latin square design – 2^2 factorial design.

(Total Lectures: 45Hours)

3. References:

1. Box G.E.P, Hunter J.S. and Hunter W.G., “Statistics for Experimenters”, John Wiley and Sons, 2005
2. Berthouex P.M and Brown L.C., “Statistics for Environmental Engineers”, CRC Press, 2002.
3. Freund J.E. and Miller I.R., “Probability and Statistics for Engineers”, Eighth Edition, Prentice–Hall of India, 2011.

4. Walpole R.E. Myers R.H., Myers S.L. and Ye K., “Probability and Statistics for Engineers and Scientists”, Pearson Education, New Delhi, 2002.
5. Johnson D. E., “Applied Multivariate Methods for Data Analysis”, Thomson & Duxbburg Press, Singapore, 2002.

4. CO-PO-PSO_Mapping

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	3	3	2	2
CO2	1	1	3	3	2	2
CO3	2	2	3	3	3	3
CO4	2	2	3	3	3	3
CO5	2	2	3	3	2	3

ELECTIVE – 4

CEEN122CLEANER PRODUCTION AND ENVIRONMENTAL MANAGEMENT

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understand the concept of sustainable development.
CO2	Create the Env management plan for industry.
CO3	Encourage the industry for pollution prevention and cleaner production.
CO4	Develop the life cycle assessment of the product of industry.
CO5	Analyze the product in terms of environmental economics.

2. Syllabus

- **ENVIRONMENT AND SUSTAINABLE MANAGEMENT (08 Hours)**
  Concepts of Sustainable Development – Indicators of Sustainability – Sustainability Strategies, Barriers to Sustainability – Resource degradation – Industrialization and Sustainable development – Socio economic policies for sustainable development
- **CLEANER PRODUCTION (08 Hours)**
  Clean development mechanism, cleaner Production (CP) in Achieving Sustainability – Principles and concepts of Cleaner Production – Role of Industry, Regulations to Encourage Pollution Prevention and Cleaner Production – Regulatory versus Market-Based Approaches
- **ENVIRONMENTAL MANAGEMENT SYSTEM IN INDUSTRY (10 Hours)**
  Source Reduction Techniques – Process and equipment optimization, reuse, recovery, recycle, raw material substitution – Preparing for the Site visits – Data and Information collection –Process Flow Diagram – Material Balance – CP Option Generation – Technical and Environmental Feasibility analysis – Economic valuation of alternatives – Total Cost Analysis – Pollution Prevention and Cleaner Production Awareness Plan – Waste audit – Environmental Statement – Green house gases and carbon credit – Carbon sequestration – Sustainable development through trade – carbon trading.
- **ENVIRONMENTAL MANAGEMENT TECHNIQUES (13 Hours)**
  Elements of Life Cycle Assessment (LCA) – Life Cycle Costing – Eco Labeling – Design for the Environment – International Environmental Standards – ISO 14001 – Environmental audit, Green building & green energy concepts and management – Industrial applications of CP, LCA, EMS and Environmental Audits – Green energy and green process management in Pharmaceutical, Construction, Textiles, Petroleum Refineries, Iron and Steel
- **ENVIRONMENTAL ECONOMICS (06 Hours)**
  Introduction – economic tools for evaluation – Economic development and social welfare consideration in socio economic developmental policies and planning.

(Total Lectures: 45Hours)

3. References

1. Bishop, P. L. (2019). Pollution prevention: Fundamentals and practice (2nd ed.). McGraw-Hill Education.
2. World Bank Group. (2018). Pollution prevention and abatement handbook: Towards cleaner production (2nd ed.). World Bank and UNEP.
3. Modak, P., Visvanathan, C., & Parasnis, M. (2018). Cleaner production audit (2nd ed.). Environmental System Reviews, Asian Institute of Technology.
4. Kirkby, J. O., Keefe, P., & Timberlake, L. (2018). Sustainable development (2nd ed.). Earthscan Publications.
5. Purohit, S. S. (2021). Green technology: An approach for sustainable environment (2nd ed.). Agrobios.

4. CO-PO-PSO_Mapping

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	2	2	1	2
CO2	1	1	3	2	1	2
CO3	2	1	3	2	2	2
CO4	2	1	3	2	3	3
CO5	2	2	3	3	3	3

INSTITUTIVE ELECTIVE

CEEC 271AI/ML BASED APPPLICATIONS IN CIVIL ENGINEERING

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Comprehend the basic principles of artificial intelligence (AI) and machine learning (ML) algorithms.
CO2	Understanding Data collection & management tools & techniques for AI/ML application to Civil Engineering.
CO3	Derive the need and benefits of using AI/ML algorithms for developing applications in Civil Engineering using big-data analysis.
CO4	Solve the real-life problems in Civil Engineering using real-time data collection and big-data analysis involving AI/ML tools.
CO5	Evaluate the performance of different AI/ML algorithms towards a given application in civil engineering.

2. Syllabus

- **INTRODUCTION TO MACHINE LEARNING** **(8 hours)**

Machine Learning Basics: Data Collection, Data Management, Big data, taxonomy of machine learning algorithms, **Supervised Learning:** Classification – Bayesian Classifier, K-nearest Neighbours, Regression- Linear Regression, Multivariate Regression, Logistic regression. Support Vector Machine (SVM) Algorithm. **Unsupervised Learning:** Clustering- K-means clustering algorithm and Hierarchical clustering algorithm. **Reinforcement Learning:** Q-Learning algorithm.

- **DATA COLLECTION APPARATUSES** **(8 hours)**

Type of data sources, Types of data, Types of sensors, Edge-devices, Introduction to microcontrollers, data communication protocols, Cloud storage and cloud computing, Local server setup, Cloud server setup, Introduction to Python, Introduction to Django server, Database setup.

- **APPLICATIONS IN CIVIL ENGINEERING** **(15 hours)**

Intelligent Transportation systems, smart mobility, shared mobility, Mobility as a Service (MaaS), Real-time data monitoring, Structural health monitoring, Fire resistance evaluation of structures, automation in water resource management, Water quality monitoring, water distribution system monitoring, air and noise pollution monitoring, Rainfall-runoff modelling, Climate change monitoring, Soil liquefaction, Forecasting foundation related parameters, Building occupancy modelling, Building information modelling, Energy demand prediction, Predictive maintenance of equipment, roads and buildings

- **APPLICATION PART I: DATA COLLECTION AND MANAGEMENT** **(7 hours)**

Image processing for real time applications in Civil Engineering**,** Description of available database across specialisations**,** Selection of sensors and microcontroller, Integration of sensors with Edge-device, Programming of Edge-devices, Programming of server in Django framework, Collection of sensor data and storing to Database, Cloud computing

- **APPLICATION PART II: BIG DATA ANALYSIS** **(7 hours)**

Selecting the appropriate ML algorithm for analysis, Data Processing, Analysing the importance of each variable in decision making,andAnalysis of processed data.

(Total Lecture : 45 Hours)

3. References:

1. Pradhan, M., & Kumar, U. D. (2023). Machine learning using Python (2nd ed.). Wiley.
2. Deka, P. C. (2022). Primer on machine learning applications in civil engineering (2nd ed.). Taylor & Francis.
3. Farrar, C. R., & Worden, K. (2021). Structural health monitoring: A machine learning perspective (2nd ed.). Wiley.
4. Soldatos, J. (2022). Building blocks for IoT analytics. River Publishers.
5. Natri, S. (2023). Django - The easy way (2nd ed.). [Publisher information not provided].
6. Holovaty, A., & Kaplan-Moss, J. (2022). The Django book (Release 2.0) (2nd ed.). [Publisher information not provided].
7. Benjamin, J. R., & Cornell, C. A. (2020). Probability, statistics, and decision for civil engineers (4th ed.). McGraw-Hill Education.
8. Washington, S. P., Karlaftis, M. G., & Mannering, F. L. (2019). Statistical and econometric methods for transportation data analysis (3rd ed.). CRC Press.
9. Johnson, R. A., & Wichern, D. W. (2022). Applied multivariate statistical analysis (7th ed.). Pearson.

4. Other Material:

1. Arduino-ESP32 (Release 2.0.2), Espressif, 2022.

5. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	3
CO2	3	2	3	3	2	2
CO3	3	3	3	3	3	3
CO4	3	3	3	3	2	3
CO5	3	2	3	3	3	3

SEMESTER – III

CEEN295 DISSERTATION PRELIMINARY

L	T	P	C
0	0	28	14

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Identify and investigate problems related to environmental issues.
CO2	Conduct the comprehensive literature review.
CO3	Propose the methodology for the identified problem.
CO4	Collate the information to prepare a report.

- Dissertation will be taken up by the student after the completion of the second semester. This is aimed at training the students to analyze independently problem assigned to them. The work may be analytical, experimental, design or combination of these.

- The dissertation preliminary report is expected to display clarity of thought, critical appreciation of the existing literature and analytical and / or experimental or design skill.

2. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	2	3	2	3
CO2	3	3	3	2	1	3
CO3	2	2	3	3	3	3
CO4	2	3	3	2	3	3

SEMESTER – IV

CEEN296 DISSERTATION

L	T	P	C
0	0	40	20

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Analyze the preliminary results and if required, modify the proposed methodology.
CO2	Conduct extensive analytical / modelling / experimental / field work.
CO3	Propose effective sustainable solution for the identified problem.
CO4	Prepare a comprehensive report and communicate through a skilful presentation.

- It is the continuation of the Dissertation preliminary. The Dissertation report is to be submitted at the end of the fourth semester.
- The main objective of dissertation work is to provide scope for original and independent study/research, to develop a theme and to demonstrate ability of using analytical approach independently. The theme or topic of dissertation should be within the framework of the environmental engineering M.Tech. programme.
- Dissertation report will be prepared by each student under the supervision of the faculty advisor and will be submitted within the specified time. The evaluation of dissertation will be based on continuous internal and external assessment comprising of presentation of the work and viva-voce examination.

2. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	1	3	2	2
CO2	3	2	2	3	2	3
CO3	3	2	3	3	2	2
CO4	1	3	3	3	1	3

Teaching and Examination Schemes with Syllabus

of

Master of Technology

in

(Civil) GeotechnicalEngineering

As per NEP

((Approved by the SEC of Senate dated August 8, 2022))

Department of Civil Engineering
Sardar Vallabhbhai National Institute of Technology, Surat

Vision and Mission of the Institute

Vision

To be one of the leading Technical Institutes disseminating globally acceptable education, effective industrial training and relevant research output

Mission

To be a globally accepted centre of excellence in technical education catalyzing absorption, innovation, diffusion and transfer of high technologies resulting in enhanced quality for all the stake holders

Vision and Mission of the Department

Vision

To be a global centre of excellence for creating competent professionals in Civil Engineering

Mission

- To provide excellent education producing technically competent, globally employable civil engineers who will be leaders in the chosen field
- To undertake research in conventional and advanced technologies fulfilling the needs and challenges of modern society
- To provide consultancy services and develop partnerships with society, industry and public organizations.
- To organize seminar, conferences, symposia and continuing education programmes for academic and field community.

Foreword

The SVNIT, Surat was established in the year 1961 and the Geotechnical Engineering Section is part of the institute since 1973. The section consists of dedicated team of 7 faculty members. The section has 6 well equipped laboratories and all faculties acquired their Doctorate from renowned universities in the field of Geotechnical Engineering like IITs, NITs etc. Beside high-quality teaching and instruction at UG and PG, the section is actively involved in basic and applied research and consultancy services. The section is providing quality technical and advisory support through consultancy to various private construction agencies, State Government, Central Government projects. Alumni from Geotechnical Engineering Section are serving at various International as well as National Level Organizations and some have been successful entrepreneurs in the fields of Geotechnical Engineering. The Geotechnical Engineering Section presents a picture of a small but fully dedicated and developed faculty contributing to all round growth of students, Institute, Industries and Society.The M. Tech. programme in Geotechnical Engineering is one of the oldest PG programmes of the institute.

The curriculum of the programme is regularly revised taking inputs from industry and alumni.The syllabus includes core courses, electives, practicals, summer training and dissertation. Through course work spread in the first two semesters, the students are exposed to various techniques and theory of geotechnical engineering. Through quizzes and assignments students' performance is continuously evaluated. Experiments are regularly updated with latest equipment and software. Dissertation spread over two semesters help students to comprehend a problem, analyse it and develop a detailed methodology to derive valid conclusions through a number of field, laboratory or simulated experiments

Programme Educational Objectives (PEOs)

The graduates of the M.Tech. Geotechnical Engineering Programme will:

- Excel in professional career and horn research skills in the field of Geotechnical Engineering
- Exhibit professionalism through lifelong learning and able to work in teams for sustainable infrastructure growth and development of the nation.
- Graduates will communicate effectively in their team, adapt to emerging technologies for sustained growth and exhibit social responsibility with professional ethics.

Programme Outcomes (POs)

The outcomes of the Master of Technology programme in Geotechnical Engineering are:

- An ability to independently carry out research /investigation and development work to solve practical problems.
- An ability to write and present a substantial technical report/document.
- Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate Master program.

Programme Specific Outcomes (PSOs)

- Students will acquire the knowledge to characterize the geotechnical site, evaluate the properties of geo-materials and design the geotechnical structures for static and dynamic loadings.
- Students will be able to address the geotechnical challenges related to excavation, geo-environmental issues, ground improvement, earth retaining structures and pavement geotechnics, using advanced tools, techniques and software with due consideration of sustainability.
- Students will be able to contribute towards multidisciplinary scientific research in the field of geotechnical engineering for infrastructure growth and development of the nation.

Teaching Scheme
M.Tech. in (Civil) Geotechnical Engineering

Sr. No.	Subject	Code	Scheme L-T-P	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
				Th.	T	P		
				Marks	Marks	Marks		
	First Semester							
1	Advanced Foundation Engineering	CEGT101	3-1-0	100	25	-	4	65
2	Slope stability and Retaining structures	CEGT102	3-1-0	100	25	-	4	65
3	Advanced Soil mechanics	CEGT103	3-1-0	100	25	-	4	65
4	**Core Elective - 1**	##	3-0-0	100	-	-	3	50
5	**Core Elective - 2**	##	3-0-0	100	-	-	3	50
6	Geotechnical Engineering laboratory	CEGT104	0-0-4	-	-	50	2	62
						Total	**20**	**357**
7	Vocational Training / Professional Experience (optional) (Mandatory for Exit)	##	0-0-10				5	200 (20 x 10)
	Second Semester							
1	Ground Improvement Techniques	CEGT201	3-1-0	100	25	-	4	65
2	Soil Dynamics & Earthquake Geotechnics	CEGT202	3-1-0	100	25	-	4	65
3	Core Elective - 3	##	3-1-0	100	25	-	4	65
4	Core Elective - 4	##	3-0-0	100	-	-	3	50
5	Institute (Open) Elective	##	3-0-0	100	-	-	3	50
6	Numerical Modelling in Geomechanics	CEGT204	0-0-4	-	-	100 40+60 * **	2	62
						Total	**20**	**357**
7	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	##	0-0-10				5	200 (20 x 10)

Sr. No.	Subject	Code	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
			Th.	T	P		
			Marks	Marks	Marks		
	Third Semester						
1	MOOC course-I*	#	#	#	#	3/4	70/80
2	MOOC cousse-II*	#	#	#	#	3/4	70/80
3	Dissertation Preliminaries	CEGT303	-	-	350$	14	560
			Total			**20-22**	**700-720**
	Fourth Semester						
1	Dissertation	CEGT403	-	-	600$	20	800

$ **Internal**: 40% and **External**: 60%
*Swayam/NPTEL

Core Elective - 1

1. CEGT110 Geosynthetics & Reinforced Soil Structure
2. CEGT111 Soil Structure Interaction
3. CETP116 Research Analytical Methods
4. CEST112 Theory of Elasticity & Plasticity

Core Elective 2

1. CEGT120 Rock Mechanics
2. CEGT121 Constitutive Modelling in Geomechanics
3. CECT111 Low Cost Construction
4. CETP117 Pavement Analysis and Design

Core Elective - 3

1. CEGT210 Finite Element Method in Geotechnical Engineering
2. CEGT211 Structural Geology

Core Elective - 4:

1. CEGT220Environmental Geotechnology
2. CEGT221 Tunnelling and Underground Structures
3. CEST213Foundation Design of Structures & Soil-structure Interaction

Institute (Open) Elective:

1 CEST230 Soil Exploration and Field Tests

2 CEEC730AI/ML Based Applications in Civil Engineering

Allotment of elective

The choice of the elective courses is primarily based on the interest of the students. Facultiesoffering the respective elective subject interact with all students and brief out the content with relevance of the subject in field or in research. On the basis of merit, students are given thefreedom to select the elective of their choice. Emphasize is made to offer maximum numberof electives in each semester, however, at least 6 students need to opt a certain elective to runit.

Assessment of Performance

Assessment of Theory Courses

The evaluation pattern for the theory courses, *as of now*, shall be as under:

Mid-semester examination: 30 marks

Assignment/Quizzes: 20 marks

Tutorials (if applicable): 25 marks

End-semester exam: 50 marks

The mid- and end-semester examinations are of 1.5 hours and 3 hours, respectively.

Assessment of Dissertation/Projects

Internal assessment of 40% weightage by guide(s) Final assessment of 60% weightage by a panel of examiners

For more details please refer to the institute website

https://www.svnit.ac.in/Data/Notice/AcademicRegulations2013-2014.pdf

Course-wise Detailed Syllabus

Semester I

CEGT101Advanced Foundation Engineering

L	T	P	C
3	1	0	4

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Interpret laboratory and field-testing results for foundation design
CO2	Comprehend soil investigation reports and suggest the suitable type of foundation
CO3	Design the suitable shallow and deep foundation for structures
CO4	Evaluate bearing capacity and settlement of shallow and deep foundations using various approaches
CO5	Apply the acquired knowledge for the design of special foundation

2. Syllabus

- **SOIL PROPERTIES & INTERPRETATIONS (06 Hours)**
  Soil properties and its applications, Interpretation of the soil parameters for foundation design, Interpretation of the soil investigation report.

- **SHALLOW FOUNDATIONS (11 Hours)**
  Stress distribution of soil, Different types of shallow foundation, Modes of failure in soil beneath foundation, Flexible and rigid foundation, Bearing Capacity of Soil, Settlement of Foundations, Shallow foundations design criteria, Case studies.

- **DEEP FOUNDATIONS (13Hours)**
  Types of pile foundation, factors affecting choice of types of piles, Load carrying capacity of single and group of piles, Group efficiency, Uplift and Lateral resistance of piles, settlement of single and group of piles, Negative skin friction, Geotechnical aspects for pile design, Secant pile, Contiguous pile, Pile load test (vertical, lateral and pull out), Deep Foundation: barrette pile, belled pile, rock socketed pile, well foundation, micro pile, batter/rake pile, fender pile, under-ream pile, large diameter

pile, different materials of pile, Construction of pile foundation, Pile driving analysis, Non-destructive test on piles.

- **FOUNDATIONS ON WEAK DEPOSITS** **(04 Hours)**

  Identification of weak soils, Problems associated with weak deposits, Foundations for expansive soil, Collapsible soils.

- **SPECIAL FOUNDATIONS** **(11 Hours)**

  Foundation on layered soil, Foundations on slope, foundations on rocks, Compensated foundation, Raft foundation, Pile Raft foundation, Annular foundation for circular structures, Concept of offshore foundations, Techno legal consideration in geotechnical engineering.

(Total Lectures: 45 hours. Tutorial: 15 hours)

3. References

1. Bowles J E "Foundation Analysis & Design" McGraw Hills Inc. New York, 5th edition 2012.
2. Nayak N V "Foundation Design Manual" Dhanpatrai & Sons, New Delhi, 2016.
3. Das B M 'Principles of Foundation Engineering' PWS Publishing Co., Boston, 2011.
4. Srinivasulu P., Vaidyanathan C.V., "Handbook of Machine Foundation", McGraw Hills Inc, 2002
5. Tomlinson, M., & Woodward, J. (2007). *Pile Design and Construction Practice*. CRC press.
6. IS 1892 (1979): Code of practice for subsurface investigations for foundations.
7. IS 6403 (1981): Code of practice for determination of bearing capacity of shallow foundations.
8. IS 1904 (1986): Code of practice for design and construction of foundations in soils: General requirements.
9. IS 8009-1 (1976): Code of practice for calculation of settlements of foundations, Part 1: Shallow foundations subjected to symmetrical static vertical loads.
10. IS 8009-2 (1980): Code of practice for calculation of settlement of foundations, Part 2: Deep foundations subjected to symmetrical static vertical loading.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	1	3
CO2	3	3	3	3	3	3
CO3	2	1	2	3	3	2
CO4	3	2	3	3	2	3
CO5	3	2	3	3	3	3

1-Low 2-Moderate 3-High

CEGT102Slope Stability and Retaining Structures

L	T	P	C
3	1	0	4

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Illustrate the basic concepts of earth pressure theory
CO2	Identify and select the suitable retention system for excavation projects
CO3	Analyse the arching in soil and its benefits in geotechnical design
CO4	Evaluate the stability of embankment slope, open cuts and natural slopes.
CO5	Applying the earth pressure theory, theory of arching and slope stability methods to analyse and design the geotechnical system involving retaining systems

2. Syllabus

- **LATERAL EARTH PRESSURE** **(06 Hours)**

  Lateral Earth Pressure at Rest, Rankine Active and Passive Earth Pressure, Coulomb's Active and Passive Earth Pressure, Lateral Earth Pressure Due to Surcharge, Inclined backfill, Circular retaining wall, and Earthquake loading**.**

- **RETAINING SYSTEM** **(09Hours)**

  Types of retaining systems. **Retaining wall**: Types of Retaining Walls, Application of Lateral Earth Pressure Theories to Design and Stability of Retaining Walls, Construction Joints and Drainage from Backfill, Retaining wall with relieving shelf. **Sheet-Pile Walls**: Cantilever Sheet-Pile Walls in sand, clay and layered soil, Anchored Sheet-Pile Walls, Free Earth Support Method for Penetration of Sandy and Clayey Soil, Holding Capacity of Anchor Plates in Sand and Clay.

- **OPEN CUTS AND DEEP EXCAVATIONS** (**08 Hours)**

  Open cuts, sheeting and bracing systems in shallow and deep open cuts in different soil types, lateral earth pressure distribution on braced-cuts, stability of braced-cuts in saturated clay, piping failures in sand cuts, Diaphragm walls, Secant Pile, Touch Pile, Contiguous Pile for deep excavations.

- **COMPONENTS OF EXCAVATIONS (06 Hours)**

  Dewatering: Ditches and sumps, well points, deep-well pumps, sand drains. Pre-stressed Ground Anchors, Modern Retaining Systems, Coffer dams: various types, analysis and design. Instrumentations for deep excavations.

- **ARCHING IN SOILS (06 Hours)**

  Theory of Arching in Soils and its Applications in design of tunnels & conduits,pressure computations around tunnels, benefits of arching, arching for other geotechnical systems.

- **SLOPE STABILITY (10 Hours)**

  Introduction, Factor of Safety, Stability of Infinite Slopes, Finite Slopes, Analysis of Finite Slopes with Plane Failure Surfaces and with Circular Failure Surfaces, Bishop's Simplified Method of Slices, Morgenstern's Method of Slices, Determination of Factor of Safety of Slopes made of Clay and Embankment on Saturated Clay, Slope protection and stabilization. Earth Dams and Embankments: choice of material, Design of filters and drains. Stability in rapid drawdown. Use of different draining conditions (CD, CU, UU) in soil for evaluating the stability of slope.

(Total Lecture Hours 45, Tutorial: 15 hours)

3. References

1. Clayton, C. R., Woods, R. I., & Milititsky, J. (2014). Earth Pressure and Earth-Retaining Structures. CRC press.
2. Budhu, M. (2008). Foundations and Earth Retaining Structures. John Wiley & Sons Incorporated.
3. Ou, C. Y. (2014). Deep Excavation: Theory and Practice. CRC Press.
4. Duncan, J. M., Wright, S. G., & Brandon, T. L. (2014). Soil Strength and Slope Stability. John Wiley & Sons.
5. Abramson, L. W., Lee, T. S., Sharma, S., & Boyce, G. M. (2001). Slope Stability and Stabilization Methods. John Wiley & Sons.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	1	1	1	1	1
CO2	2	1	2	1	1	1
CO3	1	1	1	1	1	1
CO4	3	2	2	2	2	2
CO5	3	3	3	2	2	3

1-Low 2-Moderate 3-High

CEGT103 Advanced Soil Mechanics

L	T	P	C
3	1	0	4

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Illustrate the types of soil structure and clay minerals and their characteristics.
CO2	Comprehend the effective stress, permeability and seepage in soil under different hydraulic conditions
CO3	Analyze the consolidation behavior of soil to calculate corresponding settlement
CO4	Appraise the shear strength characteristics of soil and the governing factors
CO5	Evaluate the geotechnical parameters for the design of geotechnical structures

2. Syllabus

- **CLAY MINERALOGY** **(05 Hours)** Types of Soil Structure, Clay Minerals, Characteristics and Construction of Mineral groups, Soil water.

- **PRINCIPLE OF EFFECTIVE STRESS** **(06 Hours)**
  Concept of effective stress and its necessity, Capillarity in soils; Steady state flow in soils. Effect of flow on effective stress

- **PERMEABILITY AND SEEPAGE** **(09 Hours)**
  Determination of coefficient of permeability by laboratory methods, field methods and indirect methods; Factors affecting permeability; Permeability of unsaturated soil; Seepage forces; quick sand and piping; Flow nets; Design of filters; Flow net for anisotropic and non- homogeneous soils.

- **CONSOLIDATION** **(10 Hours)**
  Mechanics of consolidation; phenomenon of consolidation; Primary & secondary consolidation settlements; one dimensional, three dimensional and radial

consolidation. Various consolidation tests and determination of parameters; Field consolidation curve; Sand drains; Smear zone

- **SHEAR STRENGTH** **(15 Hours)**

  Shear resistance; stress -strain relationship in soils; failure criteria: Mohr Coulomb's failure; Triaxial and direct shear tests; UU, CU, CD tests; shear parameters under different drainage conditions; Pore-pressure parameters; Factors affecting shear behavior of fine grained soils and coarse grained soils; Total and effective stress-strength parameters; Total and effective stress-paths; Concept of unsaturated soil mechanics and critical state soil mechanics.

(Total Lecture Hours 45, Tutorial: 15 hours)

3. References

1. Budhu, M. "Soil Mechanics Fundamentals", John Wiley & Sons Inc., New York, USA. 2015.
2. Kaniraj S R, "Design Aids in Soil Mechanics & Foundation Engineering", Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1988
3. Ranjan, G. and Rao, A.S.R., "Basic and Applied Soil Mechanics", New Age International Publishers, New Delhi, India.2008
4. Das, B.M. and Khaled S., "Principles of Geotechnical Engineering", Cengage Learning, Stamford, USA.2014.
5. Bowles, J. E, "Foundation Analysis and Design", McGraw-Hill, New York, 5th edition, 2012.
6. Lambe T.W, Whitman R.V.," Soil Mechanics", John Wiley & Sons, 1969.
7. Holtz, Robert D., William D. Kovacs, and Thomas C. Sheahan. "An Introduction to Geotechnical Engineering". Vol. 733. Englewood Cliffs: Prentice-Hall, 1981.

4. <u>CO-PO-PSO_Mapping</u>

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	3	3	3	1
CO2	3	1	3	3	3	1
CO3	3	1	3	3	3	1
CO4	3	1	3	3	3	2
CO5	3	2	3	3	2	3

1-Low 2-Moderate 3-High

CEGT110 Geosynthetics and Reinforced Soil Structures

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Comprehend the basic principles of reinforced soil for its applications in geotechnical engineering
CO2	Identify the different types of Geosynthetics and its functions
CO3	Evaluate the different engineering properties of Geosyntheticfor its applications in civil engineering
CO4	Appraise different codal provisions for reinforced geotechnical structures
CO5	Design suitable ground improvement and reinforced soil structures using Geosynthetics

2. Syllabus

- **INTRODUCTION** **(03 Hours)**

  Historical background of reinforced soil, Principles of reinforced soil through Mohr circle analysis.

- **DIFFERENT TYPES OF GEOSYNTHETICS** **(04 Hours)**

  Types of geosynthetics like geotextiles, geogrids, geonets, geocells, geo-composites, their manufacturing methods

- **TESTING METHODS FOR GEOSYNTHETICS** **(06 Hours)**

  Techniques for testing of different index properties, strength properties, Apparent Opening Size, In-plane and cross-plane permeability tests, assessment of construction induced damage and extrapolation of long term strength properties from short term tests.

- **REINFORCED SOIL RETAINING WALLS (12Hours)**

  Different types of walls like wrap-around walls, full-height panel walls, discrete-facing panel walls, modular block walls. Design methods as per BS-8006 and FHWA methods Construction methods for reinforced soil retaining walls.

- **REINFORCED SOIL SLOPES (07 Hours)**

  Basal reinforcement for construction on soft clay soils, construction of steep slopes with reinforcement layers on comptenet soils, Different slope stability analysis methods like planar wedge method, bi-linear wedge method and circular slip methods. Erosion control on slopes using geosynthetics.

- **APPLICATIONS IN FOUNDATIONS (05 Hours)**

  Binquet and Lee's approach for analysis of foundations with reinforcement layers.

- **DRAINAGE AND FILTRATION APPLICATIONS OF GEOSYNTHETICS (03 Hours)**

  Different filtration requirements, filtration in different types of soils and criteria for selection of geotextiles, estimation of flow of water in retaining walls, pavements, etc. and selection of geosynthetics.

- **PAVEMENT APPLICATION (05 Hours)**

  Pavement application: Geosynthetics for separation and reinforcement in flexible pavements, design by Giroud-Noiray approach, reflection cracking and control using geosynthetics. Use of geosynthetics for construction of heavy container yards and raiway lines.

(Total Lecture Hours 45)

3. References

1. Koerner, R.M. "Designing with Geosynthetics", Prentice Hall, New Jersey, USA, 5th edition, 2005.
2. Jewell, R.A., "Soil Reinforcement with Geotextiles", Special Publication No. 123, CIRIA, Thomas Telford. London, UK, 1996.
3. Geosynthetics - New Horizons, Eds. G.V. Rao, PK Banerjee, J.T. Shahu, G.V. Ramana, Asian Books Private Ltd., New Delhi, 2004.
4. Shukla,S. K.. "Geosynthetics and its applications" Thomas Telford, London, 2002.
5. Shukla, S. K.. "Fundamentals of Geosynthetic Engineering". CRC Press. 2006.
6. Additional Reading: Design guidelines from IRC, FHWA, BS, IS and other codal organizations.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	1	1	2	2	2
CO2	1	1	1	2	1	2
CO3	2	1	1	2	2	2
CO4	3	3	2	3	3	3
CO5	3	3	3	3	3	3

1-Low 2-Moderate 3-High

CEGT111 Soil Structure Interaction

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Illustrate a basic background of stress and displacement of soil, Scope of soil-foundation interaction analysis.
CO2	Identify situation where soil-structure interaction is likely to occur ,elastic analysis of pile and pile group for different loading condition with SSI
CO3	Evaluate behaviour of pile single pile and pile group by different spring concepts, boussinsq's method ,line load and strip load consideration.
CO4	Analyse and predict the behaviour piled raft foundation for static and dynamic loading condition
CO5	Apply the concepts of wrinker's approach and elastic continuum approach in problems associated with SSI for buildings for different foundation input motion.

2. Syllabus

- **SOIL-FOUNDATION INTERACTION** **(04 Hours)**
  Introduction to soil – stresses and displacement in soils, Soil behaviour, Foundation behaviour, Interface behaviour, Scope of soil-foundation interaction analysis

- **ELASTIC ANALYSIS OF PILE** **(07 Hours)**
  Elastic analysis of single pile, Theoretical solutions for settlement and load distribution, Analysis of pile group, axial loaded single pile and pile group, pile cap – pile-soil interactions.

- **PILE LOAD DEFLECTION** **(06 Hours)**
  Prediction for laterally loaded piles, subgrade reaction and elastic analysis, static interaction analysis of shallow and deep foundation.

- **SOIL RESPONSE MODELS (08 Hours)**Winkler model, Elastic continuum, P-Y curves, Q-Z curves and T-Z springs concepts, Elastic plastic behavior of soil, Time dependent behavior, boussinsq's method, line load, strip load consideration

- **BEAM ON ELASTIC FOUNDATION (07 Hours)**
  Pile on wrinkler's foundation, vertically loaded pile, rigid pile, evaluation of spring stiffness, non-homogeneous soil, laterally loaded pile in layered soil, piles in elastic continuum, vertically and laterally loaded pilein elastic continuum,

- **DYNAMIC SOIL-STRUCTURE INTERACTION (07 Hours)**
  Soil structure interaction of piled raft foundation for static loading and dynamic loading for homogeneous soil and for layered soil

- **ENGINEERING APPLICATION OF SOIL-STRUCTURE INTERACTION (06 Hours)**
  Foundation input motion, seismic soil structure interaction analysis based on time period for buildings, examples and case studies

(Total Lecture Hours 45)

3. References

1. Hemsley, J.A, Elastic Analysis of Raft Foundations, Thomas Telford, 1998.
2. McCarthy, D.F. Essentials of Soil Mechanics and Foundations, basic geotechnics (7th Edition), Prentice Hall, 2014.
3. Selvadurai, A.P.S., Elastic Analysis of Soil Foundation Interaction, Elsevier, 2013.
4. Poulos, H.G., and Davis, E.H., Pile Foundation Analysis and Design, John Wiley, 1990.
5. Scott, R.F. Foundation Analysis, Prentice Hall, 1981.
6. Structure Soil Interaction - State of Art Report, Institution of structural Engineers, 1978. ACI 336, Suggested Analysis and Design Procedures for Combined Footings and Mats, American Concrete Institute, Dehit, 1988.
7. Bowels, J.E., "Analytical and Computer methods in Foundation" McGraw Hill Book Co., New York

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PO3
CO1	3	3	1	2	2	1
CO2	2	2	2	2	3	3
CO3	2	2	3	3	2	2
CO4	3	1	2	2	2	2
CO5	3	3	2	3	3	2

1-Low 2-Moderate 3-High

CETP116RESEARCH ANALYTICAL METHOD

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

CO1	Perform statistical analysis of the sample data collected using different sampling techniques towards insightful inferences
CO2	Analyse different continuous and discrete probability distributions
CO3	Develop correlations by analysing univariate and multivariate data
CO4	Apply hypothesis testing techniques using different sampling distributions/tests
CO5	Solve the real-world problem with appropriate optimization tool

2. Syllabus

- **SOCIAL RESEARCH FORMULATION** **(09 Hours)**
  Design of research - Scaling techniques - Sampling design - Design of questionnaire - Data collection and statistical processing, variables, types of variables, scaling of variables, coding of variables in software tools

- **STATISTICS & PROBABILITY CONCEPTS** **(09 Hours)**
  Various probability distributions & their applications - Parameter estimation - Hypothesis testing - Random variables - Method of maximum likelihood - Hypothesis testing to compare multiple population - Statistical quality control

- **HYPOTHESIS TESTING** **(09 Hours)**
  Hypothesis testing, types of error in hypothesis, confidence interval, significance tests for comparing variances and means, tests with small and large samples, two-tail and one-tail student's t-test, analysis of variance (ANOVA), non-parametric tests (Chi-square test and Kolmogorov–Smirnov test), central limit theorem, practice with transportation data.

- **REGRESSION ANALYSIS** **(09 Hours)**
  Simple linear regression, residuals and variances, Assumptions, multiple linear regression, two stage regression, forward, backward and step-wise regression, residual analysis, correlation analysis, type of correlations, coefficient of correlation, Karl-Pearson's coefficient, multivariate data analysis, factor analysis, applications in transportation engineering, goodness-of-fit tests and curve fitting.

- **OPTIMIZATION TECHNIQUES** **(09 Hours)**

Linear programming - Simplex method - Transportation model - Concepts of non– linear programming - Decision theories – Rules - Decision under uncertainty, Applications in Transportation Engineering

(Total contact hours: 45)

3. Tutorial

1. Exercise for measuring central tendency, dispersion and shape of data, graphical representation, plots and pattern, interpretation of results, and histograms using MS office tools and other statistical packages
2. Sampling exercises, data storing, handling, cleaning, and descriptive analysis exercises by using statistical tools.
3. Exercise for fitting probabilistic distributions and hypothesis testing using statistical tools.
4. Exercise for correlation analysis, simple linear and multiple linear regressions, nonlinear regression, using statistical tools.
5. Exercise for parametric and non-parametric tests, test of significance, paired and unpaired sample tests and evaluation, using statistical tools.
6. Exercise for analysis of variance, univariate and multivariate analysis using statistical tools.
7. Exercise for solving optimization problems using solver and using statistical tools.
8. C++ /Java/python/R/MATLAB programming for statistical analysis and probability studies

4. REFERENCES:

1. Benjamin J. R., Cornell C. A., *Probability Statistics and Decision for Civil Engineers*, McGraw-Hill, 1970.
2. Kothari, C.R., *Research Methodology: Method and Techniques*, New Age International Publication, 2004.
3. Hines W. W., Montgomery D. C., *Probability and Statistics in Engineering and Management Science*, John Wiley and Sons, New York, 1990.
4. Sharma J.K., *Operation Research: Theory & Applications*, MacMillan India Ltd., 2000.
5. Bhandarkar P.L., Wilkinson T.S., *Methodology & Techniques of Social Research*, Himalaya Publishing House, 1991.
6. Simon P. Washington, Matthew G. Karlaftis, Fred, Mannering L., *Statistical and econometric methods for transportation data analysis*, CRC Press, Second Edition, 2010.
7. Washinton SP, Karlafits MG, Mannering F.L., *Statistical and econometric method for transportation data analysis*, 2nd addition, CRC Press, 2011.
8. Richard A. Johnson, Dean W. Wichern, *Applied Multivariate Statistical Analysis*, Prentice Hall, 1992.

9. Cooley, WW and Lohnes, RR, *Multivariate Data Analysis*, John Wiley, 1971.
10. Joseph F. Hair, Bill Black, Barry Babin, Rolph E. Anderson, Ronald L. Tatham, *Multivariate Data Analysis*, Prentice Hall; 2005.

5. CO-PO-PSO_Mapping

Course Objective	Program Specific Outcome			Program outcomes		
	PSO1	PSO2	PSO3	PO1	PO2	PO3
1	3	3	3	3	3	3
2	3	2	2	3	2	3
3	3	3	3	3	3	3
4	3	2	3	3	3	3
5	3	3	3	3	2	3

Note: 1: Slightly 2: Moderately 3: Substantially

CEST112: Theory of Elasticity & Plasticity

L	T	P	C
3	-	-	3

1. **Course Outcomes (COs):**

   At the end of the course students will be able to:

CO1	Comprehend and apply principles of elasticity in sufficiently rigorous manner
CO2	Evaluate the response of the structure against three-dimensional stress state at a given point
CO3	Demonstrate the skill of problem formulations in elastic analysis
CO4	Analyzethe solutions of 2D and 3D elementary problems in elasticity
CO5	Implement the concept of plasticity in a plastic analysis of structural forms

2. **Syllabus:**

- **Basic Concepts and Material Properties: (09 Hours)**

  Force,Surfaces forces, Body forces, Statical and Kinematical indeterminacy, Macroscopic and microscopic properties, Isotropy, Homogeneity, Continuity, Uniaxial stress-strain relationship, Elasticity, Anelasticity, Work hardening, Ductility, Plasticity, Creep, Relaxation, Fatigue, Hysteresis, Bauschinger effect, Elastic, plastic and Viscous models.

- **Three-dimensional Elasticity: (11 Hours)**

  Stress-tensor, Components of stress tensor,Equations of equilibrium in 2D and 3D Cartesian coordinates, Stresses on inclined plane, Transformation of stresses, Octahedral shear stresses, Stress invariants, Cauchy's stress quadric, Equilibrium equations in Polar coordinates, Strain-tensor, Components of strain tensor, Saint-Venant's Compatibility equations, Plane stress problem, Plane strain problem.

- **Formulations of Problems in Elasticity: (09 Hours)**

  Stress-strain relation in 3D field, Generalised Hook's law,Relation between elastic constants, Displacement formulation or Navier's equations, Beltrami-Michell compatibility equations,

- **Application of Theory of Elasticity: (08 Hours)**

  Airy's stress function, Solution of simply supported beams and cantilever beams subjected to different loadings by polynomials. Bending of prismatic bar, Saint-

Venant's theory of torsion, Prandtl's theory of torsion, Membrane analogy.

- **Plasticity: (08 Hours)**

  Principal stress state**,** Yield criteria and it's graphical representation,PlasticStress-strain relations and diagrams, Flow rules, Strain hardening criteria. Plastic analysis of structural forms.

[Total Theory Hours: 45]

3. References:

1. Timoshenko S. P; and Goodier J. N; "Theory of Elasticity", MC Graw Hill Book Co., Inc., New York, USA, (2016).
2. Volterra E; & Gaines J. H; "Advanced Strength of Materials", Prentice Hall Publication, New York, USA, (2012).
3. Venkatraman B; & Patel S. A; "Structural Mechanics with Introduction to Elasticity and Plasticity", MC Graw Hill Publication, New York, USA, (2014).
4. Filonenko M; "Theory of Elasticity" Borodich Dover Publication, New York, USA, (2013).
5. Wang C. T; "Applied Elasticity" Mc Graw Hill Publication, NY, USA, (2011).
6. Chakrabarty J; "Theory of Plasticity", Elsevier publications, New York, USA, (2016).
7. Budynas R.," Advanced Strength and Applied Stress Analysis", Prime Publication, New York, USA, (2016).
8. Boresi, A.P., & Sachmidt. R. J., "Advanced Mechanics of Materials", Wiley Publication, New York, USA, (2016).

4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	3
CO2	2	1	3	3	3	2
CO3	3	2	3	2	3	1
CO4	2	1	2	3	3	2
CO5	3	1	2	3	2	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEGT120Rock Mechanics

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Comprehend the origin of rocks, engineering behaviour of rock and rockmass.
CO2	Evaluate the physico-mechanical properties of rock and rockmass.
CO3	Classify the rock and rockmass using different classification systems.
CO4	Predict the strength and elastic properties of rock and rockmass using different failure criteria and empirical relations.
CO5	Design the support systems and other improvement method for rockmass.

2. Syllabus

- **INTRODUCTION** **(07 Hours)**
  Origin, interior and composition of the earth, Rock cycle, Layered formations, Measurement of attitude of formations, Joints, Faults, Stereographic projection methods, Presentation of geological data and analysis, Applications, Rock material, Engineering properties of rocks, Index properties of rocks.

- **LABORATORY TESTING IN ROCK ENGINEERING** **(07 Hours)**
  Laboratory tests for various physical and mechanical properties. Stress-Strain relationship, Direct Shear test, triaxial test, Creep test, Hardness test, Permeability test, Deformability etc.

- **INSITU STRESS** **(07 Hours)**
  Insitu stress, various methods of stress measurement, Hydrofracturing technique, Flat jack technique, Overcoring technique, Plate Loading Test, Jacking Test, Cable Jacking Test, Pressure Chamber Test, Borehole Deformation Test, Permeability Test etc.

- **FAILURE CRITERIA FOR ROCK AND ROCK MASSES** **(07 Hours)**
  Coulomb, Mohr's, Griffiths criteria, Rheology and rheological models, Mohr-Coulomb Yield Criterion, Drucker-Prager Criterion, Hoek-Brown Criterion, Murrell criteria, Bieniawski criteria, etc.

- **JOINTED ROCKMASS** **(09 Hours)**

Strength and deformability of jointed rock mass, Shear strength of jointed rocks, roughness, peak and residual strengths, Strength criteria for rockmass, Intact and rockmass classifications, Terzaghi, RQD, RSR, RMR and Q classifications, Applications.

- **IMPORTANT TOPICS IN ROCK MECHANICS (08 Hours)**
  Brittle – ductile transition, In-situ determination of elastic properties of rocks by dynamic method, Weathered rocks, Creep behaviour, Post failure behaviour, Flow through fractured rockmass, Methods to improve rock mass responses, Grouting in Rocks, Rock bolting, Rock Anchors.

(Total Lecture Hours 45)

3. References

1. Stagg K G & Zienkiewicz O C, “Rock Mechanics in Engineering Practice”, John Wiley & Sons, London, 1969.
2. Billings MP, “Structural geology. Englewood Cliffs,” New Jersey: Prentice-Hall; 1972.
3. Goodman R E, “Introduction to Rock Mechanics”, John Wiley & Sons, New York, 1989.
4. Ramamurthy T., “Engineering in Rocks for Slopes, Foundation and tunnels”, Prentice Hall of India Pvt Ltd, New Delhi, 2010.
5. Hudson J A and Harrison J P., “Engineering Rock Mechanics – An Introduction to the Principles” Elsevier, Oxford, 2000.
6. Mogi K, “Experimental rock mechanics”, CRC Press, Vol 3, 2006
7. Jaeger, Cook and Zimmerman, “Fundamentals of Rock Mechanics”, Blackwell Publishing, Fourth Edition, 2007.
8. Ghosh SK, “Structural geology: fundamentals and modern developments”, Elsevier; 2013
9. Jumikis R. Alfreds, “ Rock Mechanics” Trans Tech Publications, 1979 Koerner, R.M. "Designing with Geosynthetics", Prentice Hall, New Jersey, USA, 5th edition, 2005.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	2	1	2	1	1
CO2	2	2	2	2	1	2
CO3	2	2	3	2	2	2
CO4	2	3	3	2	2	3
CO5	3	3	3	3	3	3

1-Low 2-Moderate 3-High

CEGT121Constitutive Modelling in Geomechanics

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Illustrate the basic concepts of continuum mechanics
CO2	Comprehend the failure theory and yielding criterion of geo-materials
CO3	Illustrate the concept of critical state mechanics for development of constitutive models
CO4	Identify and select the suitable constitutive models to represent the real soils based on problem and materials involved.
CO5	Applying the appropriate constitutive models in FE analysis of geotechnical structures

2. Syllabus

- **INTRODUCTION TO CONTINUUM MECHANICS (6 Hours)**
  Stresses and strains, elastic stress-strain relations, Two-dimensional plane stress, plane strain and axisymmetric problems, equilibrium equations, compatibility equations and constitutive relations for linear elastic materials.

- **BEHAVIOUR OF REAL SOIL (6 Hours)**
  Soil anisotropy, concept of effective stress, drained and undrained conditions, Concept of different modulus of elasticity of soil, stress path, triaxial test data of real soil, Determination of different moduli of elasticity.

- **FAILURE THEORIES (4 Hours)**
  Mohr-Coulomb, Drucker-Prager, Tresca, Von-mises Failure theory and Cap models. Difference between yielding and failure.

- **PLASTICITY (6 Hours)**
  Plasticity basics: Yield criteria, Associated and non-associated flow rules, Plastic potentials, Hardening/Softening, Yielding envelopes of real soils, Stress dilatancy

theory, Plastic potential functions, Tension cut-off in soils, Work hardening plasticity theory: formulations and implementations, Hypo elasticity-plasticity.

- **CRITICAL STATE SOIL MECHANICS (11 Hours)**

  Critical state concept, Critical state parameters, Stress History, Normal compression line, Unloading-reloading line, Critical state interpretations (p’-q, v-p’ space), Ko-line, Total and Effective stress path, Determinations of Critical state parameters, Cam-clay models and simulations, Case study on use of Cam-clay models.

- **CONSTITUTIVE MODELS IN GEOMECHANICS (12 Hours)**

  Role of constitutive model in geotechnical FEA, Simple constitutive models, Elastic models (linear elasticity, non-linear elasticity and elastic anisotropy), Principles of elasto-plastic models, Mohr Coulomb model and its limitations, Other elastic-perfectly plastic models (von Mises, Tresca, Drucker-Prager), Linear Elastic and variable moduli models, No-tension models, Hyperbolic model: Hardening Soil model and Hardening soil model with small-strain stiffness, Soft soil model, Cam-Clay models. Selection of the soil model dependent on the problem and materials involved.

(Total Lecture Hours 45)

3. References

1. Ugural, A. C. and Fenster, S. K. (2012). Advanced Mechanics of Materials and Applied Elasticity, PrenticeHall, New Jersey. References
2. Mase, G. T. and Mase, G. E. (1999). Continuum Mechanics for Engineers, CRC Press, Boca Raton.
3. Puzrin, A. M. (2012). Constitutive Modelling in Geomechanics: Introduction, Springer-Verlag, Berlin.
4. Nakai, T. (2013). Constitutive Modeling of Geomaterials: Principles and Applications, CRC Press, Boca Raton.
5. Schofield, A. N., & Wroth, P. (1968). Critical State Soil Mechanics (Vol. 310). London: McGraw-hill.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	**1**	**1**	**1**	**-**	**1**	**1**
CO2	**1**	**1**	**2**	**1**	**1**	**2**
CO3	**1**	**1**	**2**	**1**	**2**	**2**
CO4	**2**	**1**	**3**	**2**	**2**	**3**
CO5	**3**	**2**	**3**	**2**	**3**	**3**

1-Low 2-Moderate 3-High

CECT111 LOW COST CONSTRUCTION

L	T	P	C
3	0	0	3

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1. Course Outcomes:

At the end of the course, students will be able to

CO1	Comprehend the aspects of low cost and sustainable infrastructure development
CO2	Identify the cost effective materials for the infrastructure development projects
CO3	Illustrate the applicability of low cost techniques and equipment in construction projects
CO4	Apply the low-cost methods for wastewater disposal systems and sanitation in rural and urban areas
CO5	Evaluate the cost benefits of using low-cost methods in construction projects

2. Syllabus

- **Concepts of low cost materials**

  Soil, Fly ash, Ferro cement, Lime, Fibers, Stone Dust, Boulders and oversize metal, Bitumen etc.

- **Low cost building material products**

  Walls; Stabilized and sun dried, soil blocks & bricks, Hollow concrete blocks, stone masonry blocks, Ferro cement partitions. Roofs ; Precast R.C. Plank & Joists roof, Precast channel roof, Precast L-panel roof, Precast Funicular shells, Ferro cement shells, Filler Slab, Seasal Fiber roof, Improved country tiles, Thatch roof.

- Low cost construction Techniques and Equipment

  Techniques; Rat trap bond construction, Precast R.C. and Ferro cement technique, Mud Technology. Equipments ; Brick molding machine, Stabilized soil block making machine and plants for the manufacturing of concrete blocks, Low Cost Roads.

- **Low cost sanitation**

  Waste water disposal system, Low cost sanitation for rural and urban areas, Ferro cement Drains

- **Cost analysis and comparison**

  Low cost materials, Low cost techniques

3. References:

1. Lal, K (2011) Handbook of Low Cost Housing, 1st Edition. New Age International Publisher
2. NBO, Handbook of Housing Statistics, Government of India.

1. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	2	2	2	3
CO2	2	1	2	2	1	3
CO3	2	2	2	2	2	3
CO4	2	2	2	1	1	3
CO5	3	3	3	1	1	3

Note: 1: Slightly 2: Moderately 3: Substantially

CETP117PAVEMENT ANALYSIS AND DESIGN

L	T	P	C
3	0	0	3

2. Course Outcomes (COs)

CO1	Comprehend the behaviour of pavement based on material characteristics
CO2	Analyse the pavement by considering various input parameters appropriately.
CO3	Select the rational method of pavement design.
CO4	Identify the design criteria based on the major failure patterns of pavement.
CO5	Design the pavement with the guidelines given by IRC, AASHTO, and PCA.

3. Syllabus

- **PAVEMENT TYPES AND MATERIALS** **(03 Hours)**

  Types and component parts of pavements; highway and airport pavements, Basic characteristics of materials used in pavements

- **STRESSES IN FLEXIBLE PAVEMENTS** **(08 Hours)**

  Layered system concepts, Stress solution for one, two- and three-layered systems, Fundamental design concepts, Stress analysis in flexible pavements using KENLAYER; problems

- **STRESSES IN RIGID PAVEMENTS** **(06 Hours)**

  Westergaard's theory and assumptions, Stresses due to curling, stresses and deflections due to loading, frictional stresses, Stresses in dowel bars and tie bars, Stress analysis in rigid pavements using KENSLABS; problems.

- **FACTORS AFFECTING PAVEMENT DESIGN** **(06 Hours)**

  Variables considered in pavement design, Classification of axle types, standard and legal axle loads, tyre pressure, contact pressure, ESWL, EWLF and EAL concepts, Traffic analysis: ADT, AADT, truck factor, growth factor, lane distribution factor, directional distribution factor and vehicle damage factor

- **DESIGN OF FLEXIBLE PAVEMENT** **(09 Hours)**

  IRC method of flexible pavement design, Asphalt Institute's methods with HMA and other base combinations, MEPDG method of flexible pavement design, Design of flexible pavement shoulders; problems.

- **DESIGN OF RIGID PAVEMENTS** **(09 Hours)**

  IRC method of plain jointed and continuously reinforced rigid pavement design , MEPDG method of rigid pavement design, Design of rigid pavement shoulders. Design of Joints; problems.

- **DESIGN OF PAVEMENT DRAINAGE** **(04 Hours)**

  Detrimental effects of water, methods for controlling water in pavements, Drainage materials: aggregates, geotextiles, pipes, Estimation of inflow, determination of drainage capacity, Drainage design for urban roads and rural roads as per IRC; problems

(Total contact hours: 45)

4. <u>REFERENCES</u>:

1. Asphalt Institute. Thickness Design – Asphalt Pavements for Highways and Streets Manual Series No. 1 (MS-1), Asphalt Institute, Kentucky, USA, 1999.
2. Das, A.Analysis of Pavement Structures, CRC Press, Taylor and Francis Group, Florida, USA, 2015.
3. Huang, Y.H. Pavement Analysis and Design, Second Edition, Dorling Kindersley (India) Pvt. Ltd., New Delhi, India, 2008.
4. IRC: 37-2012Guidelines for the Design of Flexible Pavements, The Indian Roads Congress, New Delhi, India, 2012.
5. IRC:58-2015Guidelines for the Design of Plain Jointed Rigid Pavements for Highways, The Indian Roads Congress, New Delhi, India, 2015.
6. Mallick, R.B. and T. El-KorchiPavement Engineering – Principles and Practice, CRC Press, Taylor and Francis Group, Florida, USA, 2009.
7. MEPDG-1.Mechanistic-Empirical Pavement Design Guide - A Manual of Practice, Interim Edition, American Association of State Highway and Transportation Officials, Washington, D.C., USA, 2008.

8. Papagiannakis, A.T. and E.A. MasadPavement Design and Materials, John Wiley and Sons, New Jersey, USA, 2008.
9. Yoder, E.J. and M.W. WitczakPrinciples of Pavement Design, Second Edition, John Wiley and Sons, New York, USA, 1975.

5. CO-PO-PSO_Mapping

	PSO1	**PSO2**	**PSO3**	**PO1**	**PO2**	**PO3**
1	2	3	3	3	1	3
2	2	3	1	3	2	3
3	3	3	2	3	2	3
4	3	3	1	1	2	2
5	3	2	1	3	3	3

Note: 1: Slightly 2: Moderately 3: Substantially

CEGT104 Geotechnical Engineering Laboratory

L	T	P	C
0	0	4	4

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Perform the laboratory tests for the determination of various geotechnical parameters
CO2	Perform field tests for the determination of various geotechnical parameters
CO3	Evaluate laboratory and field test results of different types of soil to identify the governing factors in geotechnical engineering

2. Practicals

1. Compaction tests - standard and modified Proctor tests
2. Permeability tests – constant head and falling head methods
3. Unsoaked and soaked CBR tests
4. Unconfined compression test
5. Vane shear and Direct shear test
6. Consolidation test
7. Triaxial compression test (UU, CU & CD)
8. Swell pressure test
9. Relative density test
10. Cyclic triaxial test
11. Field geotechnical investigations and field tests: Drilling of bore holes; undisturbed sampling and Standard Penetration Test
12. Dynamic Cone Penetration Test (large and small size)
13. Structural evaluation of road pavement using Falling Weight Deflectometer

14. The testing on rocks: Compression test, Point load test, Brazilian test, Slack durability test, and Creep test.

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3. References

1. Bowles, J. E., “Engineering Properties of Soils and their Measurement”. McGraw-Hill Book Company, Singapore.1992.
2. Lambe W., T., “Soil Testing for Engineers”, Wiley Eastern Limited, New Delhi.1993.
3. Head, K. H., “Manual of Soil Laboratory Testing” Volume 1-3, John Wiley and Sons, Singapore.1998.
4. SP-36., “Compendium of Indian Standards on Soil Engineering”, Part 1: Laboratory Testing of Soils for Civil Engineering Purposes, Bureau of Indian Standards, New Delhi.1987.
5. Bardet, J. P., “Experimental Soil Mechanics”, Prentice Hall, New Jersey .1997.
6. All relevant IS Codes.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	2	2	1	1
CO2	2	1	2	2	1	2
CO3	3	2	3	3	2	3

1-Low 2-Moderate 3-High

Semester II

CEGT210Finite Element Method in Geotechnical Engineering

L	T	P	C
3	1	0	4

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Illustrate the basic concepts of finite element (FE) analysis
CO2	Identify and select the suitable element and mesh configuration to obtain converged solution
CO3	Develop the element characteristic equation and generation of global equation
CO4	Create 1D, 2D and 3D FE models of practical problems
CO5	Applying the FE analysis on actual problem to determine induced displacements, forces, stresses and strains

2. Syllabus

- **INTRODUCTION** **(7 Hours)**

  Matrix algebra, Fundamentals of continuum mechanics, Stresses, displacements and strains in soils, solids and structures, Constitutive relations and models. Differential equations in solid and soil mechanics. Analytical and Numerical Solutions: Closed form solutions, Why study numerical analysis? Numerical methods - FDM, FEM and DEM. Introduction to FEM

- **FORMULATIONS IN FEM** **(5 Hours)**

  Matrix method, Potential energy method, Rayleigh-Ritz method, Weighted Residual method: Galerkin's Method. Errors in FEM.

- **ONE- AND TWO-DIMENSIONAL PROBLEMS** **(10 Hours)**

  Plane stress and strain, Interpolation functions, Shape functions (Lagrangian/Natural), Isoparametric elements – 1D and 2D, Numerical integration. Lagrangian elements, Infinite elements, Joint elements, Serendipity elements, Transition elements, Assembly and Solution techniques, Convergence requirements, Patch test, Examples.

- **AXISYMMETRIC PROBLEMS (5 Hours)**
  Formulation and Examples.

- **THREE-DIMENSIONAL PROBLEMS, CONSTITUTIVE MODELLING (8 Hours)**
  Formulation and Examples, Constitutive models in soils: Elastic, Elastic-plastic and No-tension models, Hyperbolic models, Introduction to Cam-Clay classes of mode.

- **FE ANALYSIS IN GEOTECHNICAL ENGINEERING(6 Hours)**
  Applications: In situ earth pressure, Construction and excavation sequences, Slope stability analysis (c-φ reduction), Seepage, Consolidation, Settlement analysis, Introduction to Dynamic consideration. Use of structural elements in Geotechnical systems.

- **TECHNIQUES FOR NONLINEAR ANALYSIS (4 Hours)**Iterative techniques: initial stress and strain methods, Tangent Stiffness methods, Stress correction method. Preprocessing and Post processing, Tutorials/Assignments.

(Total Lecture Hours 45, Tutorial: 15 hours)

3. References

1. Das B M, “Fundamental of Soil Dynamics”, Elsevier Scientific Publishing Co., New York, 1983
2. Zienkiewicz OC, Taylor RL and Zhu JZ, The Finite Element Method Its Basis and Fundamentals, Elsevier, Amsterdam, 2014.
3. Logan DL, A First Course in the Finite Element Method, Cengage-Learning, New Delhi, 2007.
4. Reddy JN, An Introduction to the Finite Element Method, McGraw-Hill, New Delhi, 2005.
5. Cook, R. D., Malkus, D. S., Plesha, M. E. and Witt, R. J. (2002). Concepts and Applications of Finite Element Analysis, John Wiley and Sons, New York.

6. Nakai, T. (2013). Constitutive Modeling of Geomaterials: Principles and Applications, CRC Press, Boca Raton.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PO3
CO1	2	1	1	-	1	1
CO2	2	1	2	-	1	1
CO3	2	2	2	-	2	2
CO4	3	3	3	2	3	3
CO5	3	3	3	3	3	3

1-Low 2-Moderate 3-High

CEGT 211 Structural Geology

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Comprehend the fundamental principles and processes in geology
CO2	Classify different type of rocks, their formation and mineral composition
CO3	Analyze geological data using Stereographic projection methods and DIPS software
CO4	Predict the effect of different structural features on the design of civil engineering structures
CO5	Evaluate the geological condition for different geotechnical structures

2. Syllabus

- **INTRODUCTION** **(8 Hours)**

  General geology, Earth and Earth processes, Origin, Interior and age determination of Earth, Physical geology, Mineralogy, Petrology. Study of Igneous, Sedimentary, and Metamorphic rocks, Silicate structures, Symmetry elements, Mineral characteristics and Families of minerals.

- **PROCESSES IN GEOLOGY** **(8 Hours)**

  Igneous processes, Bowen's reaction principle, textures and structures of plutonic and volcanic rocks, Weathering processes, Sedimentary processes, Structures of sedimentary rocks, Effects of pressure and temperature, Metamorphic rocks and structures, Geological work of Rivers, Sea/Oceans, Glaciers, Wind and Deposits, Himalayan Geology

- **STRUCTURAL ELEMENTS** **(7 Hours)**

  Structural features, Beds, Folds, Joints, Faults and their Influence on Civil structures, Rockmass description, Plate tectonics and Sea floor spreading, Continental drift, Mechanical behavior of soils and rocks, Principles of stratigraphy, Standard stratigraphic Time Scale, Indian stratigraphy, Distribution of various economic minerals, their composition and mode of occurrence.

- **MECHANICS OF FORMATION AND MEASUREMENT (11 Hours)**
  Layered formations, Attitude, true and apparent dips, topographic maps, outcrops. Measurement of attitude of formations. Folds, types of folds, classification, field study of folds, mechanics of folds, causes of folding. Joints, rock mass concept, Joint description and classification. Three point problems, Depth and thickness problems. Faults, mechanics of faulting, normal, reverse and thrusts, faults. Lineations. Foliations, Schistocity. Fault problems, Structural Associations.

- **FIELD STUDY AND GEOLOGICAL PROBLEMS (11 Hours)**
  Collection of geological data, Resistivity and Seismic Refraction methods, Scan line survey, Stereographic projection methods, Use of DIPS software, presentation of geological data and analysis, Applications, Earthquakes, Landslides, Subsidence, Erosion, Karst formations, Engineering properties of Rocks, Site selection for Slopes, Tunnels and Foundations, Rock as a construction material

(Total Lecture Hours 45, Tutorial: 15 hours)

3. References

1. Vallejo, L. G. DE.& Ferrer, M., Geological Engineering, CRC Press, Balkema, 2011.
2. Billings, B, F. G., Fundamentals of Engineering Geology, Butterworth-Heinemann, Oxford, 2016.
3. Gangopadhyay, A C Mclean, & Gribble, C D, Geology for Civil Engineers, 2nd Edition, E. & F. N. Spon, London, 1995.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	2	1	2	1	1
CO2	1	2	1	2	1	1
CO3	2	2	2	2	3	2
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3

1-Low 2-Moderate 3-High

CEGT201Ground Improvement Techniques

L	T	P	C
3	1	0	4

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Identify the mineral composition responsible for the weak soil deposits and problems associated with it.
CO2	Understand general construction procedures and inspection items for ground improvement techniques.
CO3	Analyse various index/strength properties of soil and suggest suitable ground improvement method.
CO4	Ability to design the ground improvement methods as per site requirements using various national/international codal guidelines.
CO5	Ability to prepare numerical modelling for various ground improvement techniques.

2. Syllabus

- **INTRODUCTION (06 Hours)**

  Ground Improvement: Definition, Objectives of soil improvement, Classification of ground improvement techniques, Factors to be considered in the selection of the best soil improvement technique. Weak Deposits – Identification – Problems associated with weak deposits – Mitchel chart of applicability of treatment methods – Principles – Suitable methods . Mechanical Modification, Principle of modification for various types of soils

- **DEEP GROUND IMPROVEMENT (10 Hours)**

  Insitu compaction of cohesion less soil – Dynamic compaction & blasting - Vibroflotation – stone column – Encased stone column, stone column design as per codal provisions – strengthening of sub soil by stone column installation. Lime piles.

- **HYDRAULIC MODIFICATION** **(06 Hours)**

  Definition, aim, principle, techniques. gravity drain, lowering of water table, multistage well point, vacuum dewatering. Discharge equations. Design of dewatering system including pipe line effects of dewatering, Preloading, vertical drains, sand drains. Assessment of ground condition for preloading, Electro kinetic dewatering.

- **GEOSYNTHETICS AND REINFORCED SOIL** **(07 Hours)**

  Types of geosynthetics like geotextiles, geogrids, geonets, geocells, geo-composites, their functions, applications and manufacturing methods. Index properties and Strength properties of Geosynthetics. Historical background of reinforced soil, Principles of reinforced soil. Concept of MSE wall and Reinforced Soil slopes.

- **GROUTING** **(06 Hours)**

  Types of Grouts, Desirable characteristics of Grout, Grouting methods- Permeation grouting, displacement-compaction grouting, displacement-soil fracture grouting, Jet or Replacment-displacement grouting. Grouting pressure, Grouting technology

- **SOIL STABILIZATION** **(05 Hours)**

  Soil stabilization with admixtures like lime, flyash, cement etc, Properties of chemical components, reactions and effects. Bitumen, tar or asphalt in stabilization

- **MISCELLANEOUS METHODS** **(05 Hours)**

  Micro piles, Soil nailing, Ground Anchors, ground freezing and heating methods.

(Total Lecture Hours 45, Tutorial: 15 hours)

3. References

1. Hausmann M.R. “Engineering Principles of Ground Modification” McGraw Hill Publishing Company, New York, 2013
2. Koerner, R.M. "Designing with Geosynthetics", Prentice Hall, New Jersey, USA, 6th edition, 2012.
3. Jie H., " Principles and Practice of Ground Improvement, Wiley India, 2018

4. Patra N. H., “Ground Improvement Techniques”, Vikas publishing house Pvt. Ltd., 2013.
5. Chu, Jian; Indraratna, B; Rujikiatkamjorn, C, " Ground improvement case histories: compaction, grouting, and geosynthetics", Butterworth Heinemann - Elsevier, 2015
6. Design guidelines from IS code, FHWA, BS and other codal organizations

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	1	1	1	1	1
CO2	1	1	1	1	1	1
CO3	2	2	2	3	3	2
CO4	2	2	2	2	2	2
CO5	2	2	3	3	3	2

1-Low 2-Moderate 3-High

CE202Soil Dynamics and Earthquake Geotechnics

L	T	P	C
3	1	0	4

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Illustrate a basic background on geotechnical earthquake engineering and to develop basic competence in assessing seismic hazard and in characterising earthquake actions.
CO2	Demonstrate knowledge of Free and Forced vibrations.
CO3	Investigate Dynamic Soil Properties and Stress-strain behaviour of soils under cyclic loading.
CO4	Evaluate different geotechnical structures and access the liquefaction potential of a given site.
CO5	Design various types of machine foundation and capable of selecting the types of vibration isolation materials and techniques.

2. Syllabus

- **INTRODUCTION (3 Hours)**
  Introduction to soil dynamics and geotechnical earthquake engineering, Scope and objective, Nature and types of earthquake loading, Importance of soil dynamics, Importance of Geotechnical Earthquake Engineering.

- **THEORY OF VIBRATIONS (5 Hours)**
  Basics of vibration theory, Concept of dynamic load, Earthquake load, Single degree of freedom system, Multiple degree of freedom system, Free and forced vibrations, Damped and undamped systems, Equation of Motion.

- **ENGINEERING SEISMOLOGY (4 Hours)**
  Basic Seismology, Earthquake, List of major earthquakes, Causes of earthquakes, Sources of earthquake data, Faults, Plate tectonics, Seismograph and Seismogram, deterministic and probabilistic seismic hazard analysis, local site effects, ground response analysis.

- **EARTHQUAKE MAGNITUDE AND INTENSITY (6 Hours)**

Strong Ground Motion, Size of Earthquake, Magnitude and Intensity of Earthquake, Modified Mercalli Intensity Scale, Measuring of Earthquake, Earthquake Magnitude Local (Richter) magnitude, Surface wave magnitude, Moment magnitude, Seismic energy, Correlations, Spectral Parameters: Peak Acceleration, Peak Velocity, Peak Displacement.

- **WAVE PROPAGATION (3 Hours)**
  Types of waves, Seismic Travel Time Curve, Method for locating an Earthquake's Epicentre**.**

- **DYNAMIC SOIL PROPERTIES (6 Hours)**
  Dynamic stress, deformation and strength of soils, Effect of transient and pulsating loads, Field and Laboratory evaluation of dynamic soil properties, Resonant column test, Field tests, Typical values of soil constants.
- **LIQUEFACTION OF SOIL (6 Hours)**
  Liquefaction of soils, Factors influencing liquefaction, Liquefaction potential, Liquefaction evaluation from standard penetration test, CPT and shear wave velocity of soil.

- **MACHINE FOUNDATIONS (5 Hours)**
  Types of machine foundation, General criteria, Soil dynamic parameters, Block type machine foundation (Checking of resonance and permissible amplitude), Vibration isolation techniques**.**

- **SEISMIC ANALYSIS AND DESIGN OF GEOTECHNICAL STRUCTURES (7 Hours)**
  Pseudo-static, pseudo-dynamic and time history analysis, dynamic earth pressure, response spectra, Seismic slope stability analysis, Seismic design of shallow foundation, pile foundation, and uplift ground anchors, Codal provisions.

(Total Lectures: 45 hours)

3. References

1. Prakash S., "Soil Dynamics", McGraw-Hill Book Company,1981.

2. Steven L.K.,“Geotechnical Earthquake Engineering”,Prentice Hall Inc,1996.
3. Robert W. D.,“Geotechnical Earthquake Engineering Handbook”, McGraw Hill, New York,2012.
4. TowhataI.,“Geotechnical Earthquake Engineering”,Springer-Verlag Heidelberg,2008.
5. Ishihara, K.,“Soil Behaviour in Earthquake Geotechnics”, Oxford University Press, USA,1996.
6. Srbulov,M., “Geotechnical Earthquake Engineering:Simplified Analyses with Case Studies and Examples”,Springer-Verlag,2008.
7. Barkan, D.D., “Dynamics of Bases and Foundations”, McGraw-Hill Book Company,1962.
8. IS 1893, Indian Standard Criteria for earthquake resistant Design of Structures.
9. Saran S., Soil Dynamics and Machine Foundations. Galgotia Publications, 1999.
10. IS 2974 (Part I)-1982, Code of Practice for Design and Construction of Machine Foundations, Part I- Foundation for reciprocating type machines.
11. IS 2974 (Part II)-1980, Code of Practice for Design and Construction of Machine Foundations, Part II- Foundation for Impact type Machines (Hammer Foundations).
12. IS 2974 (Part III)-1992, Design and Construction of Machine Foundations- Code of Practice, Part III- Foundation for Rotary type Machines (Medium and High Frequency).
13. IS 2974 (Part IV)-1979, Code of Practice for Design and Construction of Machine Foundations, Part IV- Foundation for Rotary type Machines of Low Frequency.

4. <u>CO-PO-PSO_Mapping</u>

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	1	3	2	1
CO2	3	2	2	2	3	3
CO3	2	2	3	3	3	2
CO4	3	1	2	2	2	2
CO5	3	3	2	3	3	2

CEGT220Environmental Geotechnology

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Identify the subsurface contamination and describe contaminant transport through geo-media.
CO2	Comprehend the characteristics of municipal solid waste and industrial by-products for their reuse in civil engineering structures.
CO3	Illustrate the application of various geosynthetics materials in the construction of landfills.
CO4	Design the solid waste disposal system and its components.
CO5	Design the slurry waste containment system using various methods of raising.

2. Syllabus

- **SUBSURFACE CONTAMINATION AND CONTAMINANT TRANSPORT (06 Hours)**

  Sources of subsurface contamination, Detection of polluted zones, Control and Remediation, Transport of contaminants by advection, diffusion, dispersion phenomena; Chemical mass transfer processes through sorption & desorption, precipitation & dissolution.

- **COMPOSITION OF SOLID WASTES (05 Hours)**

  Composition and characterization of solid waste; Determination of moisture content and organic content of MSW; Material loss fraction; Factors affecting unit weight of MSW; In-situ large Direct Shear Test for MSW; Environmental laws, regulations and assessment. ISWM Techniques.

- **CONTAINMENT OF SOLID WASTE IN LANDFILLS (18 Hours)**

  Landfills – Types, shapes, sizes; Components of landfill with their functions and requirements; typical sections of liner and cover system for hazardous and non-hazardous landfills;

  Clay liner and Compatibility: Compacted clay liner (CCL); Liner specifications; Clay mineralogy and its role in hydraulic performance of CCL; Hydraulic conductivity estimation;

Geosynthetic Clay Liner (GCL): Introduction and basic properties; Swelling and hydraulic characteristics; Solute and gas migration; Installation of GCL; Role of GCL in composite liners; Equivalency of GCL and CCL.

Geomembrane Liner (GM): Physico-mechanical response of GM; Endurance properties of GM, Service life estimation by considering ageing of GM; Leakage through GM and Installation & seaming of GM.

Design of cover systems: Introduction; Common final cover systems; Infiltration theories; Calculating percolation through cover systems; Erosion assessment; Evaluation of drainage layer capacity; Cover slope stability analysis.

Design of liner systems: Geomembrane stability against Tensile stress under self-weight, Tensile Stress under waste down-drag during filling and Adequate anchorage; Stability of soil over Geomembrane; Settlement of land fill base on soft soil; Stability for moving vehicle on ramp; Selection of drainage layer material and thickness for leachate collection.

- **CONTAINMENT OF SLURRY WASTES (06 Hours)**

  Ponds or Impoundments; Operation; Embankment construction; Methods of raising in stages; Design aspects; Environmental impact and control. Design and maintenance of ash pond for fly ash disposal.

- **VERTICAL BARRIERS FOR CONTAINMENT (04 Hours)**

  Suitable types and requirements of vertical barriers; Soil-Bentonite slurry trench walls; Cement-Bentonite slurry trench walls.

- **GEOTECHNICAL REUSE OF WASTE MATERIAL (06 Hours)**

  Waste characteristics for soil replacement; Engineering Properties of waste and geotechnical reuse; sustainability; Waste material in embankments and fillsWeak Deposits- Identification-Problems associated with weak deposits- Mitchel chart of applicability of treatment methods.

(Total Lectures: 45 hours)

3. References

1. Rowe, R. K., Quigley, R. M., Brachman, R. W. I. and Booker, J. R. "Barrier Systems for Waste Disposal Facilities", Taylor & Francis, London, UK. 2004.
2. Sharma, H. D. and Reddy, K. R. "Geoenvironmental Engineering: Site Remediation, Waste Containment and Emerging Waste Management Technologies", John Wiley & Sons, New Jersey, USA. 2004.
3. Koerner, R. M., "Design with Geosynthetics", Xlibris Corporation, USA. 2012.
4. Datta, M., Parida, B.P., Guha, B.K. and Sreekrishnan, T., "Industrial Solid Waste Management and Landfilling Practice", Narosa Publishers, Delhi. 1999.
5. Gulhati, S. K. and Datta, M., Geotechnical engineering, Tata McGraw-Hill, New Delhi, 2005.
6. Regulations and guidelines developed by USEPA, http://www.epa.gov/
7. Regulations and guidelines proposed by CPCB, Ministry of Environment & Forest, GOI, http://www.cpcb.nic.in/
8. Qian, X., Koerner, R.M. Gray, D.H. "Geotechnical Aspects of Landfill Design and Construction". Pearson, 2001.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	2	3	2	2
CO2	3	1	3	2	3	3
CO3	3	1	3	2	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3

1-Low 2-Moderate 3-High

CEGT221Tunnelling and Underground Structures

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Comprehend the design aspects of various underground structures in soil and rockmass
CO2	Identify the excavation methods for construction of underground structures in different ground conditions
CO3	Analyze the underground structures in rock and soil using elastic and elastoplastic solutions
CO4	Appraise the underground structure using empirical, observational, analytical and numerical approaches
CO5	Design the support and safety system for underground structures

2. Syllabus

- **INTRODUCTION (6 Hours)**

  Introduction to underground space and tunnelling, History, Tunnelling challenges, Types and classification of underground opening, Factors affecting design, Design methodology, Functional aspects, Size and shapes, Support systems, Codal provisions

- **EXCAVATION METHOD AND MACHINERY (10 Hours)**

  Drilling and Blasting for Underground and Open Excavations, blast operation planning, Explosive products, Blast Design, controlled Blasting techniques, Blasting damage and control, safe practices with explosives and shots. Tunnel driving techniques, TBM techniques, Bottom up and bottom down method, Tunnelling in difficult ground condition, Underground supports, theory of arching, rock loads and loads on tunnel linings, Safety aspects, Case histories.

- **ANALYSIS AND DESIGN OF UNDERGROUND OPENINGS (12 Hours)**

  Analysis of Underground openings, stresses around different shapes, initial state of stresses, Closed form solutions, BEM, FEM, Design based on analytical methods, Empirical methods based on RSR, RMR, Q systems, Observational method- NATM, Convergence-confinement method, Design based on Wedge failure and key block analysis, Design of Shafts and hydraulic tunnels.

- **DESIGN OF SUPPORT SYSTEM** **(9 Hours)**
  Tunnel support systems, Different type of supports, Standup time, Ground Reaction Curve, Stability of excavation face and Tunnel portals, Surface settlement due to underground works, Ground subsidence study, Use of appropriate software packages, Shotcreting including some case histories, Underground instrumentation and monitoring

- **TUNNEL HEALTH AND SAFETY ISSUES** **(8 Hours)**
  Construction methods, Ventilation, De-watering, Control and monitoring system: services, operations and maintenance, Lighting: specifications, maintenance, emergency lighting, Power supply and distribution, Water supply and distribution, Safety provisions, Localized hazards, Fire hazards in highway tunnels, Rapid transit tunnels. Surveillance and control system for highway tunnels. Tunnel finish, Rehabilitation: Inspection methods, Repairs, Tunnel construction contracting.

(Total Lecture Hours 45)

3. References

1. Ramamurthy T., “Engineering in Rocks for Slopes, Foundation and tunnels”, Prentice Hall of India Pvt Ltd, New Delhi, 2010.
2. Kolymbas, D., “Tunneling and tunnel mechanics: A rational approach to tunnelling”, Springer Publications. 2008.
3. Goodman, R. E., “Introduction to Rock Mechanics”, John Wiley & Sons, 1989.
4. Hoek, E. and Brown, E. T., “Underground excavations in rock”, The Institute of mining and metallurgy. 2005.
5. Brady, B. H. G. and Brown, E. T., “Rock mechanics for underground mining”, Springer Publication, 2006.
6. Obert, L. and Duvall, W.I., “Rock mechanics and the design of structures in rock”, John Wiley and Sons, 1967.

7. Chapman D, Metje, N and Stark A, “Introduction to tunnel construction”, Spon Press, Taylor and Francis, 2010.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	2	2	2	1	2
CO2	2	2	3	2	2	3
CO3	2	3	3	2	3	3
CO4	3	3	3	2	3	3
CO5	3	3	3	3	3	3

1-Low 2-Moderate 3-High

CEST213: Foundation Design of Structures & Soil-Structure Interaction

L	T	P	C
3	0	0	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Interpret laboratory and field-testing results for foundation design.
CO2	Comprehend soil investigation reports and suggest the suitable type of foundation.
CO3	Design shallow and deep foundation, various machine foundations
CO4	Evaluate bearing capacity and settlement of shallow and deep foundations using various approaches
CO5	Apply the acquired knowledge for the design of special foundation.

2. Syllabus:

- **Soil Properties, Soil Exploration and Soil Improvement Techniques (09 Hours)**

  Soil properties and its applications, Laboratory testing, Soil exploration techniques – comparisons, Sounding tests, Geophysical methods, Sampling, Interpretation of Laboratory & field Testing, liquefaction, Quick Sand Condition, Introduction to Injection and grouting, Prefabricated vertical drain, Basic of vibroflotation, stone column.

- **Introduction to Shallow Foundation and Earth Retaining Structures (07 Hours)**

  Soil Investigation Reports study, Bearing capacity of soil, classification and designing of Shallow Foundation, Settlement of Foundations, Foundation on collapsible and expansive soil, Earth Reinforcement, RE wall, Gabion wall-concept, Rock Anchoring, Diaphragm technique, Diaphargm wall with anchor, Box Pushing, Cantilever

Retaining wall & Counterfort Retaining wall, Drainage for Retaining wall, Bridge Abutment wall.

- **Introduction Deep Foundation (03 Hours)**
  Caisson foundation, Cellular cofferdam, Braced-cut and Drainage

- **Machine Foundation (08 Hours)**
  Machine foundation – Types of machine foundation, General criteria, Theory of vibration, Single degree freedom system, Soil dynamic parameters, Block type machine foundation (Checking of resonance and permissible amplitude), vibration isolation techniques

- **Pile Foundation (08 Hours)**
  Pile foundation – Types of piles, Factors affecting choice of types of piles, Pile load test, Load carrying capacity of piles, Pile group, Group efficiency, Lateral resistance of piles, settlement of piles , Negative skin friction

- **Special Foundations (10 Hours)**
  Classification of Foundation, Special foundations, Raft foundation, types of rafts, Beams on elastic foundation, Footing subjected to moments, Footing subjected to tension, Geotextiles, various methods of foundation design, Technological consideration in Geotechnical Engineering. Idealization of soil-structure interaction. Concept of Non-linear Winkler foundation.

[Total Theory Hours: 45]

3. References

1. V N S Murthy "Advanced foundation Engineering" CBS publishers and distributors, 2007.
2. B.C.Punmia "Soil Mechanics and Foundation" Laxmi Publication, New Delhi, 2012.

3. P.Purushothama Raj "Ground Improvement Techniques" Laxmi Publication, New Delhi,2020.
4. Bowles J E "Foundation Analysis & Design" McGraw Hill Inc. New York, 1988.
5. Hugh Brooks "Basics of Retaining Wall Design" HBA Publication, Newport Beach, CA, USA, 2018.
6. Das B M "Principles of Foundation Engineering" PWS Publishing Co., Boston, 2011.

4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	1	3
CO2	3	3	3	3	3	3
CO3	3	2	3	3	2	3
CO4	3	2	2	3	3	2
CO5	3	1	3	3	3	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEGT230Soil Exploration and Field Tests

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Comprehend the basics of site investigation methods and field tests and its extent for variety of structures including preliminary investigations.
CO2	Identify and suitable investigation method for soil exploration
CO3	Illustrate different specialized exploration methods based on condition and requirement
CO4	Appraise different codal provisions for field tests
CO5	Judge suitable instrumentation required for predicting the behavior of structure in soils and rocks

2. Syllabus

- **PRINCIPLES OF EXPLORATION (06 Hours)**

  Site investigation, objectives, Information required for soil investigation, Extent of Investigation for different types of structures (buildings, towers, industries, road, embankment, reservoir, Dams, retaining wall, etc.), Preliminary investigations.

- **BASICS OF EXPLORATION (07 Hours)**

Modern methods of boring and sampling; Preservation and transportation of samples; Sampling records. Investigations in marine condition. Different disturbance in soil sampling. Sample collection, data logging and handling.. Offshore investigation

- **EXPLORATION METHODS (08 Hours)**

  Electric resistivity test, , gravimetric survey, , Seismic surveys like seismic refraction test, reflection test, multi-channel analysis of surface wave test, etc., Trial pits, disturbed and undisturbed sampling, detailed bore hole investigations: types of borings and types of samplers.

- **FIELD TESTS (08 Hours)**

  Plate load test, pile load test, SPT test, CPT test, flat dilatometer test, DCPT test, Vane shear test, pressure meter test, field CBR test, core cutter, sand replacement test, nuclear probe method, block shear test.

- **INTERPRETATIONS AND CODAL PROVISIONS (08 Hours)**

  Soil profiling, interpretation of exploration data and report preparation, various standards for soil investigations.

- **INSTRUMENTATIONS (08 Hours)**

  Types of instruments used for Measurement of water table, pore pressure, LVDT, dial gauges, pressure gauges, non-contact based settlement measurements Dissertation preliminaries should clearly identify the goals & objectives and scope of the dissertation work taken up by the candidate. The focus is on proposed numericalmodelling/ experimental work/ field work. The study methodology and literature review on the dissertation topic is to be completed and a typed report is to be finalized in consultation with dissertation supervisor and submitted and presented for the assessment at the end of the semester.

(Total Lectures: 45 hours)

3. References

1. Clayton, C. R. I., Matthews, M. C. and Simons, N. E. (1995) Site Investigation (Second Edition). Oxford, Blackwell Sciences.
2. Hunt, R. E. (2005) Geotechnical Engineering Investigation Handbook (Second Edition), CRC Press Taylor & Francis Group.
3. Schnaid, F. (2009) In Situ Testing in Geomechanics : The Main Tests. Taylor & Francis.
4. Simons, N., Menzies, B. and Matthews, M. (2002) A Short Course in Geotechnical Site Investigation. Thomas Telford.
5. Dunnicliff, J. (1993) Geotechnical Instrumentation for Monitoring Field Performance. Wiley-Interscience Publication.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PO3
CO1	3	3	1	3	2	2
CO2	2	3	2	3	2	3
CO3	3	2	3	3	3	3
CO4	2	1	2	3	2	2
CO5	3	3	3	3	3	2

1-Low 2-Moderate 3-High

CECS230 AI/ML BASED APPLICATIONS IN CIVIL ENGINEERING

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Comprehend the basic principles of artificial intelligence (AI) and machine learning (ML) algorithms
CO2	Understanding Data collection & management tools & techniques for AI/ML application to Civil Engineering.
CO3	Derive the need and benefits of using AI/ML algorithms for developing applications in Civil Engineering using big-data analysis.
CO4	Solve the real-life problems in Civil Engineering using real-time data collection and big-data analysis involving AI/ML tools
CO5	Evaluate the performance of different AI/ML algorithms towards a given application in civil engineering.

2. Syllabus:

- **Machine Learning Basics: (8 hours)**

  Data Collection, Data Management, Big data, taxonomy of machine learning algorithms, Supervised Learning: Classification – Bayesian Classifier, K-nearest Neighbours, Regression- Linear Regression, Multivariate Regression, Logistic regression. Support Vector Machine (SVM) Algorithm. Unsupervised Learning: Clustering- K-means clustering algorithm and Hierarchical clustering algorithm. Reinforcement Learning: Q-Learning algorithm.

- **Data Collection Apparatuses (8 hours)**

  Type of data sources, Types of data, Types of sensors, Edge-devices, Introduction to microcontrollers, data communication protocols, Cloud storage and cloud computing, Local server setup, Cloud server setup, Introduction to Python, Introduction to Django server, Database setup.

- **Applications in Civil Engineering (15 hours)**

  Intelligent Transportation systems, smart mobility, shared mobility, Mobility as a

Service (MaaS), Real-time data monitoring, Structural health monitoring, Fire resistance evaluation of structures, automation in water resource management, Water quality monitoring, water distribution system monitoring, air and noise pollution monitoring, Rainfall-runoff modelling, Climate change monitoring, Soil liquefaction, Forecasting foundation related parameters, Building occupancy modelling, Building information modelling, Energy demand prediction, Predictive maintenance of equipment, roads and buildings

- **APPLICATION PART I: Data Collection and Management (7 hours)**
  Image processing for real time applications in Civil Engineering, Description of available database across specialisations, Selection of sensors and microcontroller, Integration of sensors with Edge-device, Programming of Edge-devices, Programming of server in Django framework, Collection of sensor data and storing to Database, Cloud computing
- **APPLICATION PART II: Big Data Analysis (7 hours)**
  Selecting the appropriate ML algorithm for analysis, Data Processing, Analysing the importance of each variable in decision making, and Analysis of processed data,

(Total Contact Hors: 45)

3. References:

1. Machine Learning using Python, by Manaranjan Pradhan, U Dinesh Kumar, Wiley.
2. A Primer on Machine Learning Applications in Civil Engineering, by Deka P C, Taylor & Francis.
3. Structural Health Monitoring: A Machine Learning Perspective, by Charles R. Farrar, Keith Worden, Wiley.
4. Building Blocks for IoT Analytics, By John Soldatos, Athens Information Technology, Greece, River Publishers.
5. Django - The Easy Way (2nd Edition), By Samuli Natri.
6. The Django Book (Release 2.0), By Adrian Holovaty, Jacob Kaplan-Moss, et al., 2013.
7. Benjamin J. R., Cornell C. A., Probability Statistics and Decision for Civil Engineers, McGraw-Hill, 1970.
8. Simon P. Washington, Matthew G. Karlaftis, Fred, Mannering L., Statistical and econometric methods for transportation data analysis, CRC Press, Second Edition, 2010.
9. Richard A. Johnson, Dean W. Wichern, Applied Multivariate Statistical Analysis, Prentice Hall, 1992.

10. *Arduino-ESP32 (Release 2.0.2)*, Espressif, 2022

4. CO-PO-PSO_Mapping

Course Objective	Program Specific Outcome			Program outcomes		
	PSO1	PSO2	PSO3	PO1	PO2	PO3
1	3	3	3	3	3	3
2	3	2	2	3	2	3
3	3	3	3	3	3	3
4	3	2	3	3	3	3
5	3	3	3	3	2	3

Note: 1: Slightly 2: Moderately 3: Substantially

CEGT204Numerical Modelling in Geomechanics

L	T	P	C
0	0	4	2

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Illustrate the application of spreadsheets, limit equilibrium, and finite element based computational geotechnics
CO2	Identify and select the appropriate models, elements and mesh configuration to obtain a converged geotechnical solution
CO3	Create finite element and limit equilibrium methods-based model of practical geotechnical engineering problems
CO4	Apply the FE analysis on actual geotechnical engineering problems to determine induced displacements, forces, stresses, and strains

2. Practicals

Excel programming for soil classification as per IS classification and determination of bearing capacity of footing.

- Evaluation of bearing capacity factors of footing with different shapes and comparison with analytical solutions.
- FE modeling of triaxial test with different constitutive models.
- Evaluation of stability of slope using LEM based different methods and FEM based c - ϕ reduction method.
- Determination of capacity of single pile, separation of end bearing and side friction of pile, and concept of pile-raft foundation.
- FE Analysis of deep excavation using sheet pile wall and diaphragm wall with and without anchors, evaluation of ground deformation and wall deformations.
- Stage construction of embankments and application of PVD drains.
- Modeling of underground structures, retaining wall and reinforced earth wall using FEM and LEM based tools.
- The construction of flow nets in earthen structure using FEM and graphical methods

(Total Practical Hours 56)

3. References

1. Potts, D. M. and Zdravkovic, L. (1999). Finite Element Analysis in Geotechnical Engineering: Theory, Thomas Telford, London.
2. Potts, D. M. and Zdravkovic, L. (2001).Finite Element Analysis in Geotechnical Engineering: Application, Thomas Telford, London.
3. Nakai, T. (2013). Constitutive Modeling of Geomaterials: Principles and Applications, CRC Press, Boca Raton.
4. Zaman, M., Gioda, G. and Booker, J. (2001). Modelling in Geomechanics, John Wiley and Sons, New York.
5. Naylor, D. J. and Pande, G. N. (1981). Finite Elements in Geotechnical Engineering, Pineridge Press, Swansea, UK.

4. CO-PO-PSO_Mapping

	PSO1	PSO2	PSO3	PO1	PO2	PO3
CO1	2	1	2	1	1	1
CO2	1	1	2	1	1	1
CO3	3	2	3	2	2	2
CO4	3	2	3	2	2	3

1-Low 2-Moderate 3-High

<u>Semester III</u>

1) <u>MOOC course-I*</u>
<u>2) MOOC cousse-II*   Internal: 40% and External: 60%</u>
<u>*Swayam/NPTEL</u>

CEGT303Dissertation Preliminaries

L	T	P	C
		7	14

The work is assigned to the students immediately after the second semester examination. Thus, the candidate starts working on the given problem during the summer vacation prior to commencement of third semester.

The preliminary work involved is related to a state-of-art literature review, identification of the area and finalization of the specific problem, with clearly defined title. The presentation of the preliminary-Part 1 is addressed as the 1st stage seminar of the proposed dissertation work. The candidate is expected to present the plan of action and review of the published work related to the area.

The candidate should submit the report of their 1st Stage and a presentation about the same will be conducted thereafter in front of internal examiners.

1. <u>Course Outcomes (COs)</u>

At the end of the course the students will be able to:

CO1	Compose a problem statement inadvancedareasof Geotechnical engineering based on review of relevant literature
CO2	Formulate objectives and scope based on identified research gap and need of the society
CO3	Develop comprehensive methodology and milestone for the research work
CO4	Design the numerical modeling/laboratory experiments/field experiments to meet the framed objectives of research
CO5	Prepare the detailed report and presentation so as to demonstrate writing and oral communication skills

2. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	3	2	3	2	3
CO2	3	3	3	3	2	3
CO3	2	3	2	3	2	3
CO4	3	3	3	3	1	3
CO5	2	2	2	1	3	3

1-Low 2-Moderate 3-High

Semester IV

CEGT401Dissertation

L	T	P	C
		10	20

The preliminary dissertation work initiated in the third semester is further extended over fourth semester to undertake data collection through field studies / laboratory experiments / simulation experiments, data analysis, modeling to draw valid inferences.

The main objective of the dissertation work is to provide opportunity as well as motivation to the students to carryout original & independent research by developing the ability of using experimental and computational facilities.

Thesis is to be prepared by each student under the guidance of faculty supervisor and finally submitted in hard bound sets as per the specified schedule.

The assessment of the dissertation work will be carried out in two stages, first during the semester (continuous evaluation) for160 marks, and final viva-voce exam for 240 marks at the end of the semester.

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Demonstrate sound technical knowledge of selected problem as a dissertation work pertaining to Geotechnical Engineering domain
CO2	Assimilate the art of literature review and appropriate usage of modern tools and techniques relevant to selected problem
CO3	Develop the methodological framework and execute the experiments related to

	Field/Laboratory/Computational investigations leading to a valid conclusion
CO4	Acquire the skill of writing and presenting comprehensive technical report/document
CO5	Exhibit tendency of lifelong learning, professional ethics and function as a member or leader in a team

2. CO-PO-PSO_Mapping

AM840	PSO1	PSO2	PSO3	PO1	PO2	PO3
CO1	3	3	3	3	1	3
CO2	3	3	2	3	2	3
CO3	3	3	3	3	1	3
CO4	2	2	2	2	3	3
CO5						

1-Low 2-Moderate 3-High

Teaching Scheme

M.Tech in WATER RESOURCES ENGINEERING

Sr. No.	Subject	Code	Scheme L-T-P	Exam Scheme Th. Marks	T Marks	P Marks	Credits (Min.)	Notional hours of Learning (Approx.)
	First Semester							
1	Core subject – 1 **Advanced Fluid Mechanics**	CEWR101	3-1-0	100	25	-	4	70
2	Core Subject – 2 **Free Surface Flow**	CEWR102	3-1-0	100	25	-	4	70
3	Core subject – 3 **Advanced Hydrologic Analysis and Design**	CEWR103	3-1-0	100	25	-	4	70
4	Elective -1	CEWR###	3-0-0	100	-	-	3	55
5	Elective - 2	CEWR###	3-0-0	100	-	-	3	55
6	**Computational Techniques in Water Resources Engineering Laboratory**	CEWR104	0-0-2	-	-	100	1	40
7	**Hydraulic Engineering Laboratory-I**	CEWR105	0-0-2	-	-	100	1	40
						Total	**20**	**400**
8	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	METMV01 METMP01	3-1-0				-	200 (20 x 10)
	Second Semester							
1	Core subject – 4 **Geospatial Techniques for Water Resources Engineering**	CEWR201	3-0-2	100	-	50	4	85
2	Core Subject – 5 **Water Resources Systems Engineering**	CEWR202	3-1-0	100	25	-	4	70
3	Elective -3	CEWR###	3-0-0	100	-	-	3	55
4	Elective -4	CEWR###	3-0-0	100	-	-	3	55
5	Institute Elective*	$$##nXX	3-0-0	100	-	-	3	55
6	Computational Hydraulics Laboratory	CEWR203	0-0-3	-	-	100	1.5	55
7	Hydraulic Engineering Laboratory-II	CEWR204	0-0-3	-	-	100	1.5	55
						Total	**20**	**430**
8	Vocational Training / Professional Experience	METMV02 METMP02	0-0-10				5	200 (20 x 10)

L: Lecture; T: Tutorial; P: Practical; Th: Theory

*to be offered to the PG students of other department and other PG Programs with the department.

Subject Code: Core, Electives, Dissertation Preliminary and Dissertation: **$$##nXX;** Vocational Training: **$$##VXX;** Professional Experience: **$$##PXX;**

$$: Department Name; **##**: M.Tech Course Identity; **n**: Year; **XX**: Core (01 to 10), Elective (11 to 70), Institute Elective (71 to 90), Vocational Training (91 to 92), Vocational Training (93 to 94), Dissertation Preliminary (95), Dissertation (96)

XX last digit odd number (for odd semester); XX last digit even number (for even semester)

Calculation of Notional Hours for the subject containing Theory, Tutorial and Practical

Example: 3-1-2: 3*15+1*15+2*15+10 (Exam)= 100

Sr. No.	Subject	Code	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
			Th.	T	P		
			Marks	Marks	Marks		
	Third Semester						
1	MOOC course – I*	φ	-	-	-	3/4	70/80
2	MOOC course – II*	φ	-	-	-	3/4	70/80
3	Dissertation Preliminaries	CEWR301	-	-	350$	14	560
			Total			**20-22**	**700-720**
	Fourth Semester						
1	Dissertation	CEWR401	-	-	600$	20	800

$ **Internal**: 40% and **External**: 60%

*Swayam / NPTEL

φ As per 66th IAAC, Dated 20th March, 2024, Resolution No. 66.34 and 61st Senate resolution No. 4, 25th April, 2024

ELECTIVES (SEMESTER 1) (Core Elective I and II)			
Code	**Course Name**	**Scheme**	**Credit**
CEWR110	Computational Techniques in Water Resources Engineering	3-0-0	3
CEWR111	Flood Control and River Training Works	3-0-0	3
CEWR112	Hydropower Engineering	3-0-0	3
CEWR113	Integrated Watershed Management	3-0-0	3
CEWR114	Stochastic Hydrology	3-0-0	3
CEWR115	Water Supply Distribution Systems	3-0-0	3

ELECTIVES (SEMESTER 2) (Core Elective III and IV)			
Code	**Course Name**	**Scheme**	**Credit**
CEWR210	Advanced Hydraulic Structures	3-0-0	3
CEWR211	Hydraulics of Alluvial Rivers	3-0-0	3
CEWR212	Irrigation and Drainage Systems Engineering	3-0-0	3
CEWR213	Ground Water Engineering	3-0-0	3
CEWR214	Computational Hydraulics	3-0-0	3
CEWR215	Climate Change Studies	3-0-0	3
CEWR216	Water Infrastructure in Smart Cities	3-0-0	3

INSTITUTE ELECTIVE-1 (SEMESTER 2)			
Code	**Course Name**	**Scheme**	**Credit**
CEWR215	Climate Change Studies	3-0-0	3
CEWR216	Water Infrastructure in Smart Cities	3-0-0	3

SEMESTER – I
CEWR101
Core 1: ADVANCED FLUID MECHANICS

L	T	P	Credit
3	1	0	4

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Identify the fluid flows and accordingly application of basic laws of fluid mechanics to solve real time problems.
CO2	Analyze viscous flow and flow instability
CO3	Appraise the boundary layer theory and its application
CO4	Analyze turbulent flow
CO5	Apply unsteady flow in pipe

2. Syllabus

EQUATIONS GOVERNING FLUID FLOW (07 Hours)
Reynolds transport theorem, law of conservation of mass-continuity equation, law of conservation of momentum- equation of motion, law of conservation of energy- energy equation.

POTENTIAL FLUID FLOW (08 Hours)
Standard flow pattern- uniform flow, source, irrotational vortex circulation, doublet, source and sink, vortex pair; source and vortex-spiral flow; source and uniform flow-flow past a half body; doublet and uniform flow-flow past a half body; source, sink and uniform flow- flow past a Rankine body; doublet and uniform flow-flow past cylinder, Doublet, vortex and uniform flow-flow past a cylinder with circulation; Magnus effect.

VISCOUS FLOW AND FLOW INSTABILITY (08 Hours)
Equation of motion–Navier-Stokes equation, Exact and approximate solutions of N-S equation, creeping motion, theory of instability of laminar flow- methods of small disturbance, stability analysis, Orr- Sommerfeld equation, solution of OSE equation- neutral stability curve, stages of transition from laminar to turbulent flow, factors affecting transition from laminar to turbulent flow.

BOUNDARY LAYER THEORY (09 Hours)
Factors affecting growth of boundary layer, momentum thickness, displacement thickness, energy thickness, order of magnitude analysis, Prandtl’s boundary layer equation, exact solution of laminar boundary layer equation for flow on a flat plate, von Karman momentum integral equation and its application in computation of boundary shear stress, drag, local and average coefficients of friction

for laminar and turbulent boundary layers, factors affecting separation of boundary layer and its control.

TURBULENT FLOW **(08 Hours)**
Characteristics of turbulent flow, types of turbulent flow, averaging procedure, Reynolds equation for turbulent flow from N-S equation, Prandtl's mixing length theory for two-dimensional parallel flows, Karman-Prandtl's universal velocity distribution, smooth and and rough turbulent flow and their velocity distributions, Moody's diagram - friction factor and its variation with Reynolds number and relative roughness.

UNSTEADY FLOW IN PIPE **(05 Hours)**
Water hammer, Rigid and elastic water column theories, methods of analysis.

[Total Hours: 45 Hours, Tutorial: 15 hours]

3. References

1. Fox, W.R., and McDonald, A.T., "Introduction to Fluid Mechanics", Wiley and Sons Inc., New York, 2003 (Sixth Edition).
2. Jain, A. K., "Fluid Mechanics", Khanna Publishers, New Delhi, 2012 (Twelfth Edition)
3. Streeter, V.L., Bedford, K. and Wylie, E. B., "Fluid Mechanics", McGraw Hill Book Company Ltd., New York, 2017 (Ninth Edition).
4. White, F. M., "Fluid Mechanics", The McGraw Hill Companies, 2016 (Eighth Edition)
5. Schlisting, H., Gersten, K., "Boundary Layer Theory", Springer Publication, 2000 (Eighth Edition)

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	1	3	2	1
CO2	3	2	1	3	2	1
CO3	3	2	1	3	2	1
CO4	3	2	1	3	2	1
CO5	3	2	1	3	2	1

CEWR102

Core 2:FREE SURFACE FLOW

L	T	P	Credit
3	1	0	4

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Compute uniform flow
CO2	Apply non-uniform flow concepts to solve the field problems
CO3	Evaluate spatially varied flow
CO4	Analyse unsteadiness and hydrodynamics of fluid flow.
CO5	Apply numerical methods for unsteady flow

2. Syllabus

UNIFORM FLOW **(06 Hours)**
Specific energy curve and its limitations, critical depth and section factor for critical and uniform flow computations, open channel flow transitions, standing wave, venturi flumes, control sections and hydraulic exponent for critical and uniform flow computations.

NON-UNIFORM FLOW **(08 Hours)**
Assumptions in GVF analysis, dynamic equation of GVF, classification of channel slopes, GVF profiles, its identification and computation, applications, Specific force curve and its application in the analysis of hydraulic jump, hydraulic jump characteristics.

SPATIALLY VARIED FLOW **(08 Hours)**
Basic principles and assumptions, differential equations, analysis of flow profiles and flow through side weirs and bottom racks.

UNSTEADY FLOW **(09 Hours)**
Waves, classification of waves, waves celerity, occurrences of unsteady flow, height and celerity of gravity waves, governing equations for one dimensional flow, St. Venant equations and numerical methods.

UNSTEADY FLOW NUMERICAL METHODS **(08 Hours)**
Method of characteristics, Finite difference methods, explicit and implicit finite difference schemes, consistency, stability.

TWO-DIMENSIONAL FLOW **(06 Hours)**
Governing equations, MacCormack scheme, Gabutti scheme, artificial viscosity, finite volume scheme, applications.

[Total Hours: 45 Hours, Tutorial: 15 hours]

3. References

1. Asawa, G. L., “Fluid Flow in Pipes and Channels”, CBS Publishers & Distributors, New Delhi, 2017.
2. Chaudhary, H. M., “Open Channel flow”, Springer, 2007 (Second Edition).
3. Chow, V. T., “Open Channel Hydraulics”, The Blackburn Press, 2009 Edition.
4. Subramanya, K., “Flow in open channels”, Fifth edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2019.
5. Srivastava, R., “Flow through open channels”, Oxford Higher Education, Oxford University Press, 2007.

5. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	3	3	2	2
CO2	3	1	3	3	2	2
CO3	3	1	2	3	2	2
CO4	2	1	2	2	1	3
CO5	2	1	2	2	1	3

CEWR103

Core 3: ADVANCED HYDROLOGIC ANALYSIS AND DESIGN

L	T	P	Credit
3	1	0	4

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1. Course Outcomes (Cos)

At the end of the Course the students will be able to:

CO1	Synthesize the solution including precipitation, evapo-transpiration and infiltration processes
CO2	Estimate flood hydrographs for gauged and ungauged catchments.
CO3	Apply flood routing models to rivers and reservoirs.
CO4	Compute IDF curves and floods of different return periods.
CO5	Design of Storm Drainage network

2. Syllabus

PRECIPITATION AND EVAPOTRANSPIRATION (12 Hours)

Global hydrological cycle, Atmospheric water, water vapour, Greenhouse effect, Computation and measurement of precipitation, missing data analysis and check on consistency of data, trend analysis, evaporation, evapo-transpiration, spatio-temporal distribution of rainfall.

FLOW THROUGH UNSATURATED ZONE (08 Hours)

Unsaturated flow models for potential infiltration rate - Horton's equation, Philips equation and Green-Ampt model, Models for actual infiltration rate, Computation of excess rainfall hyetograph from observed flood hydrograph using ϕ-index, and SCS (NRCS) curve number method.

FLOOD ESTIMATION METHODS- DETERMINISTIC APPROACHES (10 Hours)

Unit hydrograph theory, derivation of instantaneous unit hydrograph and synthetic unit hydrograph. Rational method, Project hydrology Design flood PMF storm transportation, PMP and PMF for project by using conceptual models, Introduction to glacier lake outburst flood (GLOF).

FLOOD ROUTING (07 Hours)

Lumped flow routing, distributed flow routing models including kinematic, diffusion and dynamic wave routing models. Numerical solutions of distributed flow routing models.

HYDROLOGIC STATISTICS (08 Hours)

Hydrologic statistics, Flood forecasting and flood frequency analysis. Hydrologic design of storm water drainage system, preparation

[Total Hours: 45 Hours, Tutorial: 15 hours]

3. References

1. Chow, V. T., Maidment, D. R., and Mays, L. W., “Applied Hydrology”, McGraw Hill International editions, New Delhi, 2017.
2. Subramanya, K., “Engineering Hydrology”, Fourth Edition, Tata McGraw-Hill Publishing company Ltd., New Delhi, 2017.
3. Singh, V. P., “Elementary Hydrology”, Prentice Hall, New Delhi,1991.
4. Ojha, C. S. P., Bhunya, P., and Berndtsson, P., “Engineering Hydrology”, Oxford University Press, Noida, 2008.
5. Raghunath, H. M., “Hydrology Principles, Analysis and Design”, New Age International Pvt. Ltd., New Delhi, 2015.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	3
CO2	2	2	3	2	3	2
CO3	2	2	3	2	3	2
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3

CEWR110

Core Elective 1 and 2: Computational Techniques in Water Resources Engineering

L	T	P	Credit
3	0	0	3

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1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Ascertain use of spreadsheet and statistical techniques in water resources engineering.
CO2	Apply numerical methods to water resources engineering.
CO3	Practice advanced numerical techniques in water resources engineering.
CO4	Solve water resources problems using software and hydro informatics.
CO5	Analyse complex water resources engineering problems using computational techniques.

2. Syllabus

INTRODUCTION **(03 Hours)**

Computational Techniques, Database design, Spreadsheet.

STATISTICAL TECHNIQUES **(12 Hours)**

Presentation of data, Measures of location and dispersion, Probability concepts and distribution, Tests of significance, Correlation and Regression, Selection of suitable statistical technique.

NUMERICAL METHODS **(10 Hours)**

Finite difference schemes, Method of characteristics, Finite element method, Finite volume method.

HYDRO-INFORMATICS **(12 Hours)**

Introduction, Genetic Algorithm, Artificial Neural Network, Fuzzy Logic, Other data driven methods, Virtual institute, Web based hydro informatics system

APPLICATIONS **(08 Hours)**

Application with case studies, Selection of suitable computational technique, Different types of hydraulic engineering software: Salient features, Capabilities and limitations.

[Total Hours: 45 Hours]

3. References:

1. Abbott, M. B., “Hydroinformatics: Information Technology and the Aquatic Environment”, Avebury Technical, Aldershot, 1991.
2. Chaudhry, M. H., “Open Channel Flow”, Springer Science, New York, 2007(Second Edition).
3. Grewal, B. S., “Higher Engineering Mathematics”, Khanna Publishers, New Delhi, 2015(Forty Fourth Edition).
4. Govindaraju, R. S., and Rao, A. R., (eds.) “Artificial Neural Networks in Hydrology”, Springer, 2010 (2000 Edition).
5. Rajsekaran, S., and Vijayalakshmi Pai, G.A., “Neural Networks, Fuzzy Logic and Genetic Algorithms-Synthesis and Applications”, PHI Learning Pvt. Ltd., New Delhi, 2013

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	2	2	2	3
CO2	3	1	3	2	2	3
CO3	3	1	3	2	3	3
CO4	3	1	3	3	3	3
CO5	3	2	3	3	3	3

CEWR111

Core Elective 1 and 2: FLOOD CONTROL AND RIVER TRAINING WORKS

L	T	P	Credit
3	0	0	3

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Assess morphological behaviour in alluvial rivers
CO2	Predict local scour in alluvial river.
CO3	Design river training works.
CO4	Apply Geo-Synthetics and other material in river training works
CO5	Compare flood control methods using soft computing techniques.

2. Syllabus

MORPHOLOGY AND HYDRAULICS OF ALLUVIAL RIVER (11 Hours)

Alluvial streams and their hydraulic geometry, bed level variation of alluvial streams, variation in plan form of alluvial streams, Analytical models of river morphology, Numerical models for morphological studies, flood plain analysis, morphology of some Indian rivers.

FLOOD CONTROL AND ITS ASSESSMENT (13 Hours)

Types of Floods, Different methods of Flood control, Floods in major Indian river basins, Types and design of flood forecasting and protection systems, Comparison of levees with bypass channels and off stream storage, reservoir operation for flood control and management, flood damage estimation models.

RIVER TRAINING AND FLOOD PROTECTION WORK (21 Hours)

Guide lines for planning and design of river embankments (levees), planning, design, construction and maintenance of guide banks and groynes for alluvial rivers, Application of Geo-synthetics and other materials in river training works, other structural and non-structural flood management strategies, DPR preparation for flood management.

[Total Hours: 45 hours]

3. References

1. Chow, V. T., Maidment, D. R., and Mays, L. W., “Applied Hydrology”, McGraw Hill International editions, New Delhi, 2017.
.
2. Garde, R. J., and Ranga Raju, K. G. , “Mechanics of sediment transportation and alluvial stream problems”, New age International (P) Limited, Publishers”, New Delhi, 2000.

3. Garde, R. J., “River Morphology”, New Age International Publishers, New Delhi, 2006

4. Mays, L. W., “Hydraulic Design Handbook”, Mc Graw Hill Companies, New Delhi, 1999.

5. BIS 10751(1994), 12094 (2000), 12926 (1995), 8408 (1994)

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	1	2	3	1
CO2	3	2	1	2	3	1
CO3	3	1	2	2	3	1
CO4	3	1	2	2	3	1
CO5	3	1	2	3	2	1

CEWR112

Core Elective 1 and 2: Hydropower Engineering

L	T	P	Credit
3	0	0	3

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Identify Issues related to hydropower development in India.
CO2	Assess hydropower potential of river basins.
CO3	Evaluate efficacy of hydropower plants.
CO4	Design intake structures and water conveyance system.
CO5	Able to carry out power house planning.

2. Syllabus

Introduction **(02 hours)**
Energy sources for power generation, Power scenarios, Demand and supply of power, need of hydropower, General Hydrology, Environment and Hydro Power Development.

Planning for water power development **(04 hours)**
Introduction, Objectives of planning, planning for water power development, Estimation of available water, Power duration curve, Storage and pondage, Load studies, Technical terms related to hydropower, System integrated operational studies, Load prediction, Installed capacity, Size and number of units.

Topographical Survey and Geological/Geotechnical Investigation **(04 hours)**
Geological investigations studies for water power development, Geo technical investigations studies for water power development.

Power potential studies **(06 hours)**
Economics of Hydropower development, Economic value of hydropower, Cost of water power, Total annual cost of a hydro project (hydro power tariff), Operation and maintenance of hydro plants, hydro power markets.

Water Conveyance System **(08 hours)**
Intakes: Types, Location and Alignment of intakes, Losses in Intakes, Air- Entrainment at Intakes, Inlet aeration, Trash racks, Penstocks and Pressure Shafts, Surge shafts Hydrauli Valves and Gates

Classification and types of hydropower plants **(10 hours)**
Classifications, types, Storage power development, components of storage power development, economic aspects, social and rehabilitation aspects, Run-Off-River power Development, types of ROR, components of run-off-river power development, Run-of-power development on canal falls, Underground and pumped storage power plants, advantages, types and location of underground power station, its components, types of layout, limitations of underground power plants. Essential requirements of pumped storage power plant (PSPP), economics of PSPP, Cost of power generation.

Power House Planning **(07 hours)**
General layout of the power house and arrangement of hydropower units, Number and sizes f units, space allocation and dimensions, Super structure, Indoor, Semi-outdoor and Outdoor powerhouse, Lighting and Ventilation, Variation in design of power house, Safety requirements, Operation and maintenance of hydro plants.

Small Hydro Power Development **(04 hours)**
Introduction, Advantages of small hydropower, Classification of small hydropower, Components of small hydropower development, Choice of units, Economics of small hydropower schemes.

[Total Hours: 45 Hours]

3. References:

1. Dandekar, M. M., and Sharma, K. N., "Water Power Engineering", Vikas Publishing House, New Delhi,2013 (Second edition).
2. Deshmukh, M.M., "Water Power Engineering, Dhanpat Rai Publications", New Delhi, 1998.
3. Nigam, N. C., "Handbook of Hydropower Engineering", Nem Chand and Sons, Roorkee, 1999.
4. Sharma, R. K. and Sharma, T. K., "Water Power Engineering", S.Chand & Company, New Delhi, 2003.
5. Varshney, R.S., "Hydropower Structures", Nem Chand and Bros., Roorkee (U.P.), 2014.

4.CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	1	2	1	1
CO2	2	1	2	2	2	2
CO3	2	2	1	2	1	3
CO4	2	2	2	2	2	2
CO5	3	3	2	1	2	1

CEWR113
Core Elective 1 and 2: INTEGRATED WATERSHED MANAGEMENT

L	T	P	Credit
3	0	0	3

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Assess behavior of Watershed
CO2	Describe Watershed and Hydro-geomorphology
CO3	Develop suitable models for various types of Watersheds
CO4	Plan the watershed conservation practices
CO5	Apply GIS technique for Watershed Management

2. Syllabus

INTRODUCTION TO WATERSHED (05 Hours)
Definition and its components, Need of watershed management, Identification of watershed problems, Sustainability with watershed management, Watershed assessment concept, Comprehensive watershed management concepts.

BEHAVIOUR OF PHYSIOGRAPHY IN WATERSHED ASSESSMENT AND MANAGEMENT (05 Hours)
Physiography and physiographic regions – Geology, Soil, Topography, Climate, Precipitation, Hydrologic cycle.

WATERSHED AND HYDRO-GEOMORPHOLOGY (10 Hours)
Watershed Classifications, Stream classifications, watershed hydrology, Surface water assessment, Rainfall-runoff analysis, Groundwater assessment, infiltration and its measurement, Erosion process: factors affecting erosion, types of erosion, soil erosion models.

WATERSHED HYDROLOGY AND MODELLING (10 Hours)
Drainage area, Time-of-concentration and watershed lag, Runoff routing, Modelling process, Case study of sensitivity analysis of watershed management and planning.

SOIL AND WATER CONSERVATION (10 Hours)
Physical measures for watershed management by soil and water conservation, Storm water and flood management, Drought management, Integrated watershed management.

Geographical Information System **(05 Hours)**
Use of GIS and DEM for Watershed Assessment, GIS models its data requirement and limitations for Watershed assessment and analysis.

[Total Hours: 45 Hours]

3. References:

1. Murthy, J.V.S., “Watershed Management, New Age International (P) Limited Publishers”, New Delhi, Reprint 2017(Second Edition).
2. FAO : Watershed Management and Field Manuals, UN, Rome, 1990.
3. Menon, S. V., “Watershed Management: Case Studies”, ICFAI University Press, 2008.
4. Tideman, E. M., “Watershed Management – Guidelines for Indian conditions”, Omega Scientific Publishers, New Delhi, 2007 (Eleventh Edition).
5. DeBarry, P. A., “Watersheds: Processes, Assessment and Management”, Hoboken, NJ: Wiley, 2004(First Edition).

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	2	1	2	3
CO2	2	1	1	2	2	1
CO3	3	2	2	1	2	2
CO4	3	3	1	3	2	2
CO5	2	2	1	3	1	3

CEWR114

Core Elective 1 and 2: STOCHASTIC HYDROLOGY

L	T	P	Credit
3	0	0	3

1. Course Outcomes

At the end of the Course the students will be able to:

CO1	Apply knowledge of stochastic hydrology.
CO2	Appraise basic concepts of probability theory
CO3	Elaborate various types of time series analyses
CO4	Explain various types of stochastic models
CO5	Fit probability distribution to hydrologic data

2. Syllabus

INTRODUCTION **(02 Hours)**

Stochastic hydrology, Applications of stochastic hydrology.

FUNDAMENTALS OF STATISTICS **(10 Hours)**

Concept of probability, Discrete and continuous variables, Probability distributions including fitting to hydrological data.

TIME SERIES ANALYSIS **(08 Hours)**

Definitions and classification of time series. Stochastic processes. Components of time series. Trend analysis. Periodicity. Auto-correlation and spectral analysis. Frequency analysis.

STOCHASTIC MODELS **(13 Hours)**

Univariate models: classification of models, univariate annual models with normal and other distributions, univariate annual models obeying Hurst’s law, univariate seasonal models. Multivariate models: multisite annual models, multisite AR models for seasonal flows, MA models, ARIMA models, non-stationary processes.

CASE STUDIES **(12 Hours)**

Examples related to fitting probability distributions. Trend analysis, Spectral analysis. Stochastic models in hydrologic forecasting.

[Total Hours: 45 Hours]

3. References:

1. Kottegoda, N. T., “Stochastic Water Resources Technology”, The Macmillan Press Ltd., 1980.
2. Singh, V. P., “Handbook of Applied Hydrology”, Second Edition, McGraw-Hill, New York, 2016.
3. Yevjevich, V., “Stochastic Processes in Hydrology”, Water Resources Publications, Fort Collins, Colorado, 1972.
4. Hann C.T., “Statistical Methods in Hydrology”, Wiley–Blackwell, 2002 (Second Edition).
5. Clarke R. T., “Mathematical Models in Hydrology”, FAO, 1973.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	1	2	1	1	1
CO2	1	1	2	1	1	1
CO3	1	1	2	1	1	1
CO4	1	1	2	1	1	1
CO5	3	2	3	3	2	3

CEWR115

Core Elective 1 and 2: Water Supply Distribution Systems

L	T	P	Credit
3	0	0	3

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1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Identify different intake structures and water treatment processes
CO2	Understand parameters involved in design of water distribution system
CO3	Design water distribution system
CO4	Optimize water distribution system.
CO5	Analyse surge in the pressurized water supply network.

2. Syllabus

INTRODUCTION **(04 Hours)**
Introduction to Intake structure, Water Quality, Hydraulics of water treatment processes.

TYPE OF DISTRIBUTION SYSTEMS **(08 Hours)**
Equivalent pipe, parameters in distribution system analysis, parameters interrelationship, Formulation of equation, Gravity and Rising Main, Location and Design Principles.

ANALYSIS OF WATER DISTRIBUTION SYSTEM **(10 Hours)**
Methods of analysis: (i) Hardy-Cross Method (ii) Newton-Raphson method and (iii) Linear Theory Method (iv) Gradient Method.

DESIGN AND OPTIMIZATION OF WATER DISTRIBUTION SYSTEM **(13 Hours)**
Design: Trial and error method of design, cost-head loss ratio method. Optimization using linear programming techniques, Surge analysis in water distribution systems, Pump duty stations and detailing valves, Pressure transients in pipe flow.

CASE STUDIES **(10 Hours)**
Case studies on new Water Distribution Systems, Rehabilitation systems, DPR preparation of a water supply system including operation and maintenance through SCADA.

[Total Hours: 45]

3. References:

1. Bhave, P. R., “Optimal Design of Water Distribution Networks”, Narosa Publishing House, New Delhi, 2003.

2. Streeter, V. L. and Wylie, E. D., “Fluid Transients in Systems”, Pearson., 2010.
3. Bhave, P. R., and Gupta, R., “Analysis of Water Distribution Networks”, Narosa Publishing House, New Delhi and Alpha-Science Publication, UK, 2006.
4. CPHEEO (1999), Manual on Water Supply and Treatment, Central Public Health and Environmental Engineering Organisation, Ministry Housing and Urban Affairs (Previously known as Ministry of Urban Development, New Delhi, Third Edition.
5. IS 10500:2012, Drinking Water-Specification, Second Revision, 2012.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	1	2	3	1
CO2	3	2	1	2	3	1
CO3	3	2	1	2	3	1
CO4	3	1	2	2	3	1
CO5	3	1	2	3	2	1

CEWR104 **COMPUTATIONAL TECHNIQUES IN WATER RESOURCES ENGINEERING LABORATORY**	L	T	P	Credit
	0	0	4	2

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Ascertain use of spreadsheet and statistical techniques in water resources engineering.
CO2	Apply numerical methods to water resources engineering.
CO3	Practice advanced numerical techniques in water resources engineering.
CO4	Solve water resources problems using software and hydro informatics.
CO5	Analyze complex water resources engineering problems using computational techniques.

2. Syllabus

1. Application of spread sheet for hydrology / irrigation problem **(06 Hours)**

2. Application of spread sheet for water resource engineering **(04 Hours)**

3. Statistical analysis of given hydrology / irrigation problem **(06 Hours)**

4. Statistical analysis of given water resource engineering problem **(04 Hours)**

5. Application of numerical methods in water resource engineering **(06 Hours)**

6. Application of advanced numerical methods in water resource engineering **(06 Hours)**

7. Application of Hydro-informatics (IWRIS) **(06 Hours)**

8. Study of commonly used softwares related to water resource engineering **(06 Hours)**

9. Use of software for solving of water resource engineering problem **(06 Hours)**

10. Case study of computational techniques application **(04 Hours)**

11. Writing code for the specific water resources application **(06 Hours)**

[Total Hours: 60 hours]

3. References:

1. Abbott, M. B., “Hydroinformatics: Information Technology and the Aquatic Environment”, Avebury Technical, Aldershot, 1991.
2. Chaudhry, M. H., “Open Channel Flow”, Springer Science, New York, 2007(Second Edition).
3. Grewal, B. S., “Higher Engineering Mathematics”, Khanna Publishers, New Delhi, 2015(Forty Fourth Edition).
4. Govindaraju, R. S., and Rao, A. R., (eds.) “Artificial Neural Networks in Hydrology”, Springer, 2010 (2000 Edition).
5. Rajsekaran, S., and Vijayalakshmi Pai, G.A., “Neural Networks, Fuzzy Logic and Genetic Algorithms-Synthesis and Applications”, PHI Learning Pvt. Ltd., New Delhi, 2013

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	2	2	2	3
CO2	3	1	3	2	2	3
CO3	3	1	3	2	3	3
CO4	3	1	3	3	3	3
CO5	3	2	3	3	3	3

CEWR105

Hydraulic Engineering Laboratory – I

L	T	P	Credit
0	0	4	2

1. Course Outcomes

At the end of the Course the students will be able to:

CO1	Synthesize acquired theoretical knowledge with experimental observations for open channel flow.
CO2	Measure boundary layer characteristics and flow resistance on streamlined and bluff bodies.
CO3	Simulate experimentally rainfall and surface flows.
CO4	Simulate experimentally subsurface flow.
CO5	Analyse pressure transients.

2. Syllabus

Experiments related to the following aspects of hydraulic engineering:

1. Development of uniform flow in open channel **(6 Hours)**

2. Measurement of velocity distribution in open channel using Pitot tube and plotting of isovels and computation of α and β. **(6 Hours)**

3. Establishment of subcritical, critical and supercritical flows in open channel, plotting of specific energy diagram. **(6 Hours)**

4. Characteristics of hydraulic jump in open channel. **(6 Hours)**

5. Measurement and computation of gradually varied flow profiles in open channel. **(6 Hours)**

6. Rainfall and runoff characteristics using rainfall simulator. **(6 Hours)**

7. Infiltrometer to study infiltration capacity of different types of soil. **(6 Hour**s)

8. Measurement of boundary layer thickness on flat plate. **(6 Hours)**

9. Measurement of drag and lift force coefficient for cylinder and spheres. **(6 Hours)**

10. Development of Synthetic Unit Hydrograph and flood hydrograph using CWC method **(6 Hours)**

[Total Hours: 60 Hours]

3. References:

1. Asawa, G. L., Laboratory Work in Hydraulic Engineering, New Age International Private Limited, 2016.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	2
CO2	3	2	3	3	3	1
CO3	3	2	3	3	3	2
CO4	3	2	3	3	3	2
CO5	3	2	3	3	3	2

SEMESTER – II

CEWR201
Core 4: GEOSPATIAL TECHNIQUES FOR WATER RESOURCES ENGINEERING

L	T	P	Credit
3	0	2	5

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1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Appraise the fundamentals of Remote Sensing
CO2	Employ Digital Image processing
CO3	Practice fundamentals and processes of GIS
CO4	Apply GPS technology and different methods of measurements
CO5	Solve complex civil engineering applications using Geospatial Techniques

2. Syllabus

INTRODUCTION **(01 Hours)**
Introduction to geospatial techniques - Benefits and applications of geospatial techniques

REMOTE SENSING **(09 Hours)**
Fundamentals of remote sensing - Energy interactions - Ideal remote sensing systems, - Fundamentals of interpretation - Basic equipments used for interpretation - Elements of air photo interpretation - Interpretation keys - Different types of sensors - Platforms and remote sensing images

DIGITAL IMAGE PROCESSING **(05 Hours)**
Characteristics of a digital image –Digital Image processing techniques– Image registration – Digital image interpretation techniques

GEOGRAPHICAL INFORMATION SYSTEMS **(14 Hours)**
Introduction - Geo referenced data - Data input and output - Data quality and management - GIS analysis functions - Implementation of GIS - Principles and methods of data collection – Digital Elevation Models

GLOBAL POSITIONING SYSTEM **(08 Hours)**
Earth Surface, datum – Co-ordinate systems - Segments of GPS System - GPS receivers and its components - Different methods of observation

ENGINEERING APPLICATIONS **(08 Hours)**
Application of Remote Sensing, GIS and GPS in different areas of Civil Engineering, Software in Geospatial Techniques, Use of Google Earth Engine, Applications using drones.

[Total Hours: 45 hours]

3. References:

1. Lillesand, T.M., Kiefer, R. W., and Chipman, J., "Remote Sensing and Image Interpretation", John Willey & Sons, New York, 2015.
2. Chandra, A.M. and Ghosh, S.K., "Remote Sensing and Geographical Information System", Alpha Science International Ltd, 2015(Second Edition).
3. Srivastava, G.S., "An Introduction to Geoinformatics", Mc Graw Hill Education (India) Pvt. Ltd., New Delhi, 2014
4. Agrawal, N.K., "Essentials of GPS",BS Publications, 2012.
5. Lo, C.P., and Yeung, A.K.W., "Concept and Techniques of Geographical Information Systems", PHI Learning Pvt. Ltd., New Delhi, 2008

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	2	2	2	3
CO2	3	1	3	2	2	3
CO3	3	1	3	2	3	3
CO4	3	1	3	2	3	3
CO5	3	2	3	3	3	3

LIST OF PRACTICALS

1. Study of different equipments used for image interpretation **(03 Hours)**

2. Study and interpretation of various remotely sensed data products / images **(03 Hours)**

3. Delineation of drainage patterns in the given study area **(03 Hours)**

4. Study of ERDAS Imagine software **(03 Hours)**

5. Study of ARC GIS software **(03 Hours)**

6. Digital image processing using software **(03 Hours)**

7. Geo referencing of the given area / image using software **(03 Hours)**

8. Study of GPS receiver and measurement of point, line and area **(03 Hours)**

9. Study and application of Pathfinder software **(03 Hours)**

10. Application / case study of geospatial techniques in WRE **(03 Hours)**

[Total Practical Hours: 30 hours]

CEWR202
Core 5: WATER RESOURCES SYSTEMS ENGINEERING

L	T	P	Credit
3	1	0	4

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Appraise system components and its significance
CO2	Evaluate different alternatives of water resources system
CO3	Implement project optimality conditions for the water resources project
CO4	Apply soft computing techniques to optimize water resources problems
CO5	Simulate water resources systems

2. Syllabus

INTRODUCTION (06 Hours)
Introduction to water resources system and system planning, Systems approach its advantages and limitations.

ECONOMICS OF WATER RESOURCES SYSTEMS (09 Hours)
Principles of Engineering Economics, Mathematics of economic analysis, Discounting factors and discounting techniques, Feasibility of water resources project, Selection of an alternative projects, Benefit cost analysis, Internal rate of return, Legal consideration in economic analysis, Conditions of project optimality.

CONVENTIONAL OPTIMIZATION TECHNIQUES (09 Hours)
Optimization: Functions of a single variable, Optimization: Functions of multiple variables, Constrained optimization, Kuhn-Tucker conditions, Linear Programming by graphical and simplex methods, Dynamic Programming and Stochastic Optimization techniques, Applications of LP and DP to water resources engineering problems, Optimum operation model for reservoir systems by incremental dynamic programming, Sequence of multipurpose projects. Information about the software's used to solve LP problems.

SOFT COMPUTING TECHNIQUES FOR WATER RESOURCES (12 Hours)
Optimization using fuzzy sets and Fuzzy Logic, Genetic Algorithm and Artificial Neural Network, Applications of Fuzzy Logic, Genetic Algorithm and ANN to water resources engineering

SIMULATION OF WATER RESOURCES SYSTEMS (06 Hours)
Operation of system based on If-Then rules, Case studies on reservoir simulation for competing objectives, Mathematical models for large scale multipurpose projects, River basin simulation, Performance evaluation: reliability, resiliency and vulnerability, Water resources system simulation models.

SYSTEM SENSITIVITY AND PERFORMANCE CRITERIA **(03 Hours)**
Variability, Sensitivity, Uncertainty analysis, Performance Criteria, Quantifying performance criteria, Multi criteria analyses, Statistical performance criteria.

[Total Hours: 45 Hours, Tutorial: 15 hours]

3. References:

1. Loucks, D. P., Beek, E. V., Stedinger, R. J.., Dijkman, J. P.M., and Villars, M. T., "Water Resources Systems Planning and Management: An Introduction to Methods, Models and Applications". Deltares, UNESCO-IHE, Springer, 2017.
2. James, L. D., and Lee, R. R., "Economic of Water Resources Planning", McGraw Hill, 1971.
3. Vedula, S. and Mujumdar, P. P., "Water Resources System", Tata McGraw Hill Company, 2005.
4. Raju, K.S. and Kumar, D. N., Multicriterion Analysis in Engineering and Management. PHI Learning Pvt. Ltd., 2014.
5. Goldberg, D.E., "Genetic Algorithm in Search, Optimization and Machine learning Technique", Addison Wesley, Reading Mass, 1989.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	2	1	2
CO2	3	3	3	2	3	2
CO3	2	2	2	1	1	1
CO4	3	2	3	1	1	3
CO5	3	1	3	2	3	3

CEWR210 **Core Elective 3 and 4: ADVANCED HYDRAULIC STRUCTURES**	**L**	**T**	**P**	**Credit**
	3	**0**	**0**	**3**

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Plan the selection of dam site, reservoir capacity and reservoir operation.
CO2	Identify the methods of hydraulic structure design.
CO3	Design of hydraulic structures.
CO4	Analysis of weir and barrages, canal regulating structures.
CO5	Design and selection of cross drainage works and energy dissipaters.

2. Syllabus

Planning of Water Resources Project **(05 Hours)**

Planning and investigations of reservoir and dam sites, Choice of dams, preparation and protection of foundation and abutments, dam safety and hazard mitigation.

Gravity Dam **(10 Hours)**

Forces acting on solid gravity dam, modes of failures, stability analysis, elementary and practical profile of gravity dam, internal stresses and stress concentrations in gravity dam, joints, seals, keys in gravity dams.

Embankment Dam **(10 Hours)**

Classification of embankment dam, Homogeneous and zoned embankment dams, factors influencing design of embankment dams, criteria for safe design of embankment dam, steps in design of embankment dam, seepage analysis and its control through dam and its foundation, design considerations for rock fill dam, instrumentation.

Spillways and Energy Dissipaters **(08 Hours)**

Capacity of spillways, components and profile of different types of spillways, Non-conventional type of spillways, selection and design of energy dissipaters, spillway aerator.

Diversion Headwork **(07 Hours)**

Components of diversion head works and their functions, design of weirs and barrages on permeable foundations

Design of Canal and Canal Structure **(05 Hours)**

Canal regulation structures and design of cross drainage works, canal falls, operation and maintenance of canals.

Review of codes of practice

[Total Hours: 45 Hours]

3. References:

1. USBR, Design of gravity dams, A Water Resources Technical Publication, Denver, Colorado, 1976.

2. Asawa, G. L., "Irrigation and water resources engineering", New Age International Publishers, New Delhi, 2014.

3. Creager, W. P., Justin, J. D., and Hinds, J., "Engineering for dams", Nemchand and Brothers, Roorkee, 1995.

4. Khatsuria, R. M., "Hydraulics of spillways and energy dissipaters", CRC Press, 2005 (First Edition).

5. Novak, P., Moffat,A.I.B., Nalluri,C., Narayanan,R., "Hydraulic Structures", CRC Press,2006 (Fourth Edition).

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	1	3	2	1
CO2	3	2	1	3	2	1
CO3	3	2	1	3	2	1
CO4	3	2	1	3	2	1
CO5	3	2	1	3	2	1

CEWR211
Core Elective 3 and 4: HYDRAULICS OF ALLUVIAL RIVERS

L	T	P	Credit
3	0	0	3

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Classify and estimate bed forms and flow resistance in alluvial rivers.
CO2	Estimate incipient motion conditions and sediment loads in alluvial rivers.
CO3	Design of lined and unlined channels using sediment transport concepts.
CO4	Analyse Hydraulic geometry of Alluvial Rivers
CO5	Predict bed level variations in alluvial rivers.

2. Syllabus

PROPERTIES AND INCIPIENT MOTION OF SEDIMENTS (6 Hours)

Nature of sediment problems, Origin and formation of sediments, individual and bulk properties of sediments, competent velocity, lift force and critical tractive stress concept on cohesion less and cohesive soils; regimes of flow.

FLOW RESISTANCE (5 Hours)

Resistance to flow in alluvial streams, resistance relations based on total resistance and division of resistance into grain and form resistance, preparation of stage discharge curves for alluvial streams, velocity distribution in alluvial channel, sediment Petrography (Sediment sampling)

BED LOAD TRANSPORTATION (08 Hours)

Bed load computation by empirical equations, dimensional considerations and semi theoretical equations for uniform and non-uniform sediments, saltation.

SUSPENDED LOAD TRANSPORTATION (07 Hours)

Mechanism of suspension, general equations of diffusion. Integration of sediment distribution equation, Differences between actual and theoretical exponents, prediction of reference concentration, Method of integrating curves of concentration and velocity. Simple relations for suspended load, Effect of temperature on suspended load, Wash load, Non-equilibrium transport of suspended load, Computation of total loads.

STABLE CHANNEL DESIGN **(07 Hours)**
Design of lined and unlined channels for carrying clear and sediment laden water.

ALLUVIAL RIVER MODELS **(12 Hours)**
Hydraulic geometry of alluvial streams, bed level variation of alluvial streams, aggradations and degradation models, reservoir sedimentation, local scours.

[Total Hours: 45 Hours, Tutorial: 15 hours]

3. References:

1. Shen, H. W., "River Mechanics", Vol. I & II, Water Resources Publication, Colorado, 1971.
2. Garde, R. J., and Ranga Raju, K. G., "Mechanics of Sediment transportation and Alluvial Stream Problems", New Age International (P) Limited, New Delhi, 2000 (Third edition).
3. Garde, R. J., "River Morphology", New Age International Publisher, New Delhi, 2006.
4. Raudkivi, A. J., "Loose boundary hydraulics", Pergamon Press, Oxford (U. K.), 2nd edition, 1976
5. Yalin, M.S., "Mechanics of Sediment Transport", Pergamon Press, Oxford (U K), 1977.

4.CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	2	3	2	3	2
CO2	3	2	3	2	3	2
CO3	3	2	3	3	3	2
CO4	2	2	3	2	3	2
CO5	3	2	3	3	3	3

CEWR212
Core Elective 3 and 4: IRRIGATION AND DRAINAGE SYSTEMS ENGINEERING

L	T	P	Credit
3	0	0	3

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Select appropriate irrigation technique.
CO2	Describe Soil-Water-Crop Relationship
CO3	Develop suitable models for various irrigation methods.
CO4	Design drainage system for irrigated lands.
CO5	Apply soil conservation measures and reclamation of salt affected land.

2. Syllabus

INTRODUCTION **(06 Hours)**
Water resource in India and its present utilization, Development through five year plans, Roles of various commissions on irrigation and agriculture, National water policy, Types of irrigation, Irrigation methods and quality of irrigation water.

SOIL-WATER-CROP RELATIONSHIP **(08 Hours)**
Determination of soil moisture, Estimation of consumptive use and frequency of irrigation, Irrigation efficiencies for economical use of water, Design of various irrigation methods, Assessment of water charges, Conjunctive use of surface and ground water, Multi-crop irrigation scheduling.

MODELLING OF IRRIGATION SYSTEMS **(08 Hours)**
Governing equations and their solutions, Computation of inundation front, Cumulative infiltration estimation, Modelling for sprinklers and other methods of irrigation, Water Audit in irrigation systems.

SALT-AFFECTED LAND AND ITS RECLAMATION **(08 Hours)**
Salt accumulation in soil water, Classification of salts affecting the soils and their characteristics, Reclamation of saline and alkaline soils, Leaching and salinity control.

DRAINAGE OF IRRIGATED SOILS **(08 Hours)**
Need and purpose of drainage, Water logging of agricultural land and its reclamation, Steady state and transient designs of surface and sub-surface drainage systems, Drainage by wells.

SOIL EROSION AND CONSERVATION **(07 Hours)**
Water and wind erosion, Design of various types of soil conservation measures.

[Total Hours: 45 Hours]

3. References:

1. Asawa, G. L., “Irrigation and Water Resources Engineering”, New Age International Publishers, New Delhi, 2005.
2. Yaron, D., “Salinity in Irrigation and Water Resources”, Morcel Dekker Inc. New York, 1981.
3. Michael A. M., “Irrigation Theory and Practice”, S Chand publication, New Delhi, 2008 (Second Edition).
4. Richard, H., and Cuenca, “Irrigation System Design: An Engineering Approach”, Prentice Hall, Englewood Cliffs, New Jersey, 1989.
5. Majumdar, D. K., “Irrigation Water Management Principles and Practice”, PHI Publication New Delhi, 2013(Second Edition).
6. Central Water Commission,, “Guideline for Computing the Water Use Efficiency [WUE] of the Irrigation Projects, Performance Overview & Improvement Organisation, CWC.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	2
CO2	3	3	1	2	2	3
CO3	1	2	2	3	3	1
CO4	1	3	3	3	2	2
CO5	3	2	1	1	1	3

CEWR213

Core Elective 3 and 4: Ground Water Hydrology

L	T	P	Credit
3	0	0	3

1. Course Objectives

At the end of the Course the students will be able to:

CO1	Explain the occurrence of ground water
CO2	Understand the principles of well hydraulics and computation of aquifer yield
CO3	Identification and conceptualization of Artificial recharge of ground water and Groundwater modeling techniques
CO4	Analyse the problem of salt water intrusion
CO5	Assess transport of pollutants in ground water

2. Syllabus

INTRODUCTION (08 Hours)
Occurrence of ground water, geological formations as aquifers, types of aquifers, ground water movement, Darcy's law, permeability and its measurement, tracing of ground water movement, fundamental equations for steady and unsteady ground water flow, flow nets, Ground Water Scenario of India.

WELL HYDRAULICS (15 Hours)
Steady and unsteady flow in confined, semi-confined and unconfined aquifers, radial flow, superposition, multiple well system. Different methods of well construction; construction of well casings and screens, natural and artificial gravel packed wells. Safe yields, estimation, pumping and recuperation tests, Infiltration galleries.

ARTIFICIAL RECHARGE OF GROUND WATER (05 Hours)
Ground-water replenishment, Artificial recharge of ground water, different methods, merits, demerits, selection criteria for various methods, cone of depression.

GROUNDWATER MODELING TECHNIQUES (08 Hours)
Porous media models, analog models, electric analog models, digital computer models

SALT WATER INTRUSION (05 Hours)
Concept, interface and its location, control of intrusion.

POLLUTANT TRANSPORT IN GROUND WATER (04 Hours)
Pollutant transport, Plume Transport, source identification, tracer methods.

[Total Hours: 45 Hours]

3. References:

1. Todd, D. K., and Mays, L. W., “Groundwater Hydrology”,John Wiley publishers, 2011 (Third edition).
2. Bear J., “Hydraulics of Groundwater”, Dover Publications, 2013.
3. Raghunath, H. M., “Groundwater and Well Hydraulics”, New Age International Publishers, Delhi, 2007 (Third Edition)
4. Rastogi, A. K., “Numerical Groundwater Hydrology”. Ulhas Phatak for Penra International (I) Pvt. Ltd., Mumbai, 2007.
5. Driscoll, F. G., “Groundwater and Wells”, Johnson Filtration Systems Inc., Minnesota: 1986 (Second edition).

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	1	3	2	2
CO2	2	1	1	1	2	1
CO3	1	2	2	2	1	3
CO4	2	3	3	2	1	3
CO5	1	1	3	2	1	2

CEWR214

Core Elective 3 and 4: COMPUTATIONAL HYDRAULICS

L	T	P	Credit
3	0	0	3

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Recall concepts of fluid motion.
CO2	Derive and apply appropriate flood wave routing models.
CO3	Solve partial differential equations using numerical methods.
CO4	Apply numerical methods for flood waves, flow through saturated porous media and closed conduit flows.
CO5	Solve the real-world problems related to water flow

2. Syllabus

BASIC CONCEPTS OF FLUID MOTION (11 Hours)
Basic Concepts – Lagrangian and Eulerian methods of describing fluid motion, acceleration and deformation of fluid elements, Laws governing fluid motion, continuity, Euler's equation, Energy equation, Saint Venant equation, classification of partial differential equations.

NUMERICAL TECHNIQUES FOR SOLUTION OF PARTIAL DIFFERENTIAL EQUATION (18 Hours)
Review of linear algebra, solution of simultaneous linear algebraic equations-matrix inversion, solvers-direct methods, elimination methods, ill conditioned systems, Gauss-Seidel method, successive over relaxation method, Finite difference method, Finite element method, Finite volume method

ENGINEERING APPLICATIONS (16 Hours)
Application to water resources problems in open channel flows, Pressure Flow, ground water flows, and unsaturated flows through porous media.

[Total Hours: 45 Hours]

3. References:

1. Gerald, C.F., and Wheatley, P.O., "Applied Numerical Analysis", Pearson Education India, 2007 (Seventh Edition)
2. Choudhary, M. H., "Open Channel Flows", Springer, 2007 (Second Edition).
3. Abbott, M. B., "Computational Hydraulics", Pitman Publishing House, 1979.

4. Cunge, J. A., Holly, F. M., Verway, A., “Practical Aspects of Computational River Hydraulics”, Pitman Publishing House, 1980.
5. Pinder, G., and Gray, W. G., “Finite Element Simulation in Surface and Subsurface Hydrology”, Academic Press, New York, 1997.
6. Hoffman, D. H., “Numerical Methods for Engineers and Scientists”, CRC Press, Boca Raton, 2001 (Second Edition)

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	1	2	3	1
CO2	3	2	1	2	3	1
CO3	3	1	2	2	3	1
CO4	3	1	2	3	2	1
CO5	3	1	2	3	2	1

CEWR215

Core Elective-3 and 4: CLIMATE CHANGE STUDIES

L	T	P	Credit
3	0	0	3

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Understand basics of weather, climate, climate variability, climate change and its impact
CO2	Describe various layers of atmosphere, heat balance of earth atmosphere system, variation of temperature and soil temperature, thermal time and thermal extremes and carbon cycle
CO3	Elaborate the extreme climate events and modelling of climate change
CO4	Apply statistical methods in hydro-climatology
CO5	Study impact and mitigation measures

2. Syllabus

INTRODUCTION **(04 Hours)**
Hydrological cycle, Green house effect, Weather, Climate, Climate variability, ENSO, IOD and climate change, Impacts of climate change, Sources of data for climate studies.

FUNDAMENTALS OF CLIMATE CHANGE STUDY **(10 Hours)**
Overview of earth's atmosphere, Layers of atmosphere, Temperature, radiation and variation; Heat-balance of earth atmosphere system, Temporal variation of air temperature, Temperature change in soil, Thermal time and temperature extremes, Carbon cycle, Urban heat island.

EXTREME CLIMATE EVENTS **(05 Hours)**
Floods, Cloud burst, Droughts and Drought indicators, Heat waves, Sea level Rise, Compound Extremes.

CLIMATE CHANGE **(06 Hours)**
Introduction, Causes of climate change, Modelling of climate change, General circulation models, RCM, IPCC scenarios.

STATISTICAL METHODS IN HYDRO-CLIMATOLOGY **(08 Hours)**
Trend analysis, Empirical orthogonal functions, Principal component analysis, Canonical correlation, Statistical downscaling.

IMPACT AND MITIGATION MEASURES **(12 Hours)**

Regional Information on climate Change, observed impacts from climate change, vulnerability and exposure of ecosystems and people, risk in near term (2021-2040), mid to long term risks (2041-2100), complex, compound and cascading risks and impacts of temporary overshoot, Mitigation and development pathways in near to mid-term, long term mitigation pathways, mitigation potential across sectors and systems, societal aspects of mitigation and mitigation in the context of sustainable development.

[Total Hours: 45 Hours]

3. References:

1. Bonan, G. B., "Ecological Climatology : Concepts and Applications", Cambridge University Press, 2008.
2. Storch H.V., and Zweirs F.w., "Statistical Analysis in Climatic Research", Cambridge, 1999. 999.
3. Mujumdar,P.P., and Kumar,D.N., "Floods in Changing Climate", Cambridge university press,2012 (First Edition).
4. McGuffie, K., and Henderson-Sellers, "A Climate Modeling Primer", Wiley, 2005 (Third Edition).
5. IPCC (2022) "Sixth Assessment Reports", Intergovernmental Panel on Climate Change, Geneva.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	1	2	1	1	1
CO2	1	1	2	1	1	1
CO3	1	1	2	1	1	1
CO4	3	2	3	2	2	2
CO5	1	1	2	1	1	1

CEWR216

Core Elective-3 and 4: WATER INFRASTRUCTURE IN SMART CITIES

L	T	P	Credit
3	0	0	3

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Analyse Water Distribution Network
CO2	Design Storm Water Network
CO3	Plan Sewerage and Effluent Collection Network
CO4	Apply the integrated flood management practices
CO5	Resolve the water related infrastructure layout conflicts.

2. Syllabus

URBAN WATER ISSUES (03 Hours)
Water requirement, water availability, water budget, water balance, Zero liquid discharge concept and implementation, Preparation of DPR.

WATER DISTRIBUTION NETWORK (08 Hours)
Life cycle cost of distribution network, design and analysis of water distribution network.

SEWERAGE AND EFFLUENT COLLECTION NETWORK (09 Hours)
Design of sewerage network, Design of effluent collection network

STORM WATER DRAINAGE NETWORK AND INTEGRATED FLOOD MANAGEMENT (11 Hours)
Selection of IDF, Design of Storm water network with innovation, Flood plain delineation, integrated flood management practice, Low Impact Development.

Urban Lakes and Reservoirs (4 Hours)
Quality and Quantity Assessment, rehabilitation and restoration of urban water bodies

SMART WATER MANAGEMENT TECHNOLOGIES AND CONFLICTS (10 Hours)
Human-machine interface, wireless sensors, remote monitoring solution, SCADA, Priority of water related infrastructure, conflicts, resolution of conflicts based on hydraulics of flow

[Total Hours: 45 Hours]

3. References:

1. Rossmiller, R. L., "Storm water design for sustainable development", Mc.Graw-Hill Education, 2013(First Edition)
2. Bhave,P.R., and Gupta R., "Analysis of Water Distribution Networks", Alpha Science International Ltd.2006
3. Central Public Health and Environmental Engineering Organization (CPHEEO), Manual on Sewerage and Sewage Treatment Part A: Engineering, Ministry of Housing and Urban Affairs (Previously known as Ministry of Urban Development), New Delhi
4. Central Public Health and Environmental Engineering Organization (CPHEEO), Manual on Water Supply and Treatment, Ministry of Housing and Urban Affairs (Previously known as Ministry of Urban Development), New Delhi
5. Central Public Health and Environmental Engineering Organization). Ministry of Housing and Urban Affairs, Government of India, Manual on Storm Water Drainage System, Volume I-PART A: Engineering Design, Ministry of Housing and Urban Affairs (Previously known as Ministry of Urban Development), New Delhi

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	2	2	3	1
CO2	3	1	2	2	3	1
CO3	3	1	2	2	3	1
CO4	3	2	1	3	2	1
CO5	3	2	1	3	1	2

CEWR203

Computational Hydraulics Laboratory

L	T	P	Credit
0	0	4	2

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Synthesize acquired theoretical knowledge through simulation of open channel flow.
CO2	Simulate the computationally the hydrologic system.
CO3	Integrate the hydrologic and hydraulic system through computer simulation.
CO4	Analyse the water distribution system.
CO5	Optimize the reservoir operation through simulation.

2. Syllabus

1. Analysis of steady state water surface profile using HEC-RAS. **(07 hours)**
2. Analysis of unsteady state flood wave using HEC-RAS. **(09 hours)**
3. Hydrologic modelling of catchment using HEC-HMS. **(07 hours)**
4. Integration of hydrologic (HEC-HMS) and hydraulic models (HEC-RAS). (**09 shours)**
5. Water Distribution network analysis using LOOP. **(07 hours)**
6. Water distribution network analysis using Water GEMs. **(07 hours)**
7. Water hammer analysis using Bentley Hammer. **(07 hours)**
8. Reservoir optimization through linear programming solution using LINGO. **(07 hours)**

[Total Hours: 60 Hours]

3. References:

1. USAEC (US Army Corps of Engineers), HEC-RAS River Analysis System Hydraulic Reference Manual Ver. 5.0 (2016)
2. USAEC (US Army Corps of Engineers) , HEC-HMS Users Manual (2022)
3. LINGO the modeling language and optimizer, user guide, 2011, Chicago.
4. Water GemsV8i, User’s Guide, 2017.
5. Hammer V8i, User’s Guide, 2017.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	2	3	2	1
CO2	3	1	2	3	2	1
CO3	3	1	2	3	2	1
CO4	3	1	2	3	2	1
CO5	3	1	2	3	2	1

CEWR204

Hydraulic Engineering Laboratory-II

L	T	P	Credit
0	0	4	2

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1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Synthesize acquired theoretical knowledge with experimental observations for mobile bed channels.
CO2	Estimate experimentally the submergence characteristics of flow measuring structures in open channels.
CO3	Simulate experimentally hydraulic transients.
CO4	Measure experimentally the hydraulic conductivity and cone of depression for an unconfined aquifer
CO5	Demonstrate the fresh water – soil water interface

2. Syllabus

1. Measurement of discharge using Venturi flume for free and submerged flow conditions. **(06 hours)**
2. Measurement of discharge using Broad-crested weir for free and submerged conditions. **(06 hours)**
3. Incipient motion of sediments in mobile boundary channel. **(06 hours)**
4. Flow through porous media using ground water flow unit. **(06 hours)**
5. Measurements of bed shear stress by Preston tube. **(06 hours)**
6. Seepage analysis of earthen dam using electrical analogy. **(06 hours)**
7. Water Hammer Pressure and Surge tank Analysis. **(06 hours)**
8. Cavitation demonstration and analysis. **(06 hours)**
9. Measurement of soil moisture using tensiometer. **(06 hours)**
10. Hele-Shaw apparatus to study fresh water – soil water interface. **(06 hours)**

[Total Hours: 60 Hours]

3 References:

Asawa, G. L., "Laboratory Work in Hydraulic Engineering", New Age International Private Limited, 2016.

4 CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	2	1
CO2	1	2	3	3	2	1
CO3	3	1	2	3	2	1
CO4	3	1	2	3	2	1
CO5	3	1	2	3	2	1

SEMESTER – III

CEWR301

Dissertation (Preliminaries)

L	T	P	Credit
0	0	-	14

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Identify and investigate problems related to water resources.
CO2	Conduct the comprehensive literature review.
CO3	Identify research gap and decide objectives of research work.
CO4	Propose a methodology for solving the identified problem.
CO5	Plan experimental and/or numerical investigation to meet the objective.

2. Syllabus (560 Hours)

Dissertation Preliminaries should clearly identify the goals/objectives and scope of the dissertation work taken up by the student. Details of data identification and field surveys should be clearly highlighted. The study approach and literature review should be discussed. A report shall be submitted at the end of the semester, which shall be assessed.

[Total Hours: 560 hours]

3. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	2	1	1	2
CO2	2	2	3	2	2	2
CO3	2	1	2	2	1	1
CO4	2	2	3	2	2	2
CO5	2	1	2	2	2	2

SEMESTER – IV

CEWR401

Dissertation

L	T	P	Credit
0	0	-	20

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1. Course Outcomes (COs)

At the end of the course the students will be able to:s

CO1	Examine the preliminary results and possible modifications in proposed methodology.
CO2	Conduct extensive analytical / modelling / experimental / field work.
CO3	Propose an effective sustainable solution for the identified problem.
CO4	Analyse the data with advanced tools and synthesize the outcomes.
CO5	Prepare comprehensive dissertation report.

2. Syllabus **(800 Hours)**

Develop model for experimental or computer programme using advanced tools for analysis and arrive the results. Obtain the result of the work carried out, discuss the results, infer the conclusions from the results with respect to the subject and report preparation.

Discuss the research work, infer the conclusions and submit the dissertation.

The dissertation report shall be submitted at the end of the semester, which shall be assessed as per the guidelines fixed by the Hon'ble Senate of the Institute.

(Total Hours: 800 hours)

3. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	2	1	1	1
CO2	2	1	2	2	2	1
CO3	2	2	3	2	2	1
CO4	3	2	3	3	3	2
CO5	2	3	3	2	2	2

Teaching Scheme

M.Tech. in Structural Engineering

Sr. No.	Subject	Code	Scheme L-T-P	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
				Th.	T	P		
				Marks	Marks	Marks		
	First Semester							
1	Structural Dynamics	CEST101	3-1-0	100	25	-	4	65
2	Computer Methods of Analysis	CEST102	3-1-0	100	25	-	4	65
3	Experimental Stress Analysis	CEST103	3-1-0	100	25	-	4	65
4	Elective -1	CEST###	3-0-0	100	-	-	3	50
5	Elective -2	CEST###	3-0-0	100	-	-	3	50
6	Structural Engineering Lab	CEST104	0-0-4	-	-	50	2	62
						Total	**20**	**357**
7	Vocational Training / Professional Experience (optional) (Mandatory for Exit)	CESTV01 CESTP01	0-0-10				5	200 (20 x 10)
	Second Semester							
1	Advanced Design of Concrete Structures	CEST105	3-1-0	100	25	-	4	65
2	Earthquake Resistant Design of Structures	CEST106	3-1-0	100	25	-	4	65
3	Elective -3	CEST###	3-1-0	100	25	-	4	65
4	Elective -4	CEST###	3-0-0	100	-	-	3	50
5	Institute Elective	CEST###	3-0-0	100	-	-	3	50
6	Computer Modelling Analysis and Design Lab	CEST107	0-0-4	-	-	100 40+60 * **	2	62
						Total	**20**	**357**
7	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	CESTV02 CESTP02	0-0-10				5	200 (20 x 10)

Sr. No.	Subject	Code	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
			Th. Marks	T Marks	P Marks		
	Third Semester						
1	MOOC course-I*	#	#	#	#	3	70
2	MOOC course-II*	#	#	#	#	3	70
3	Dissertation Preliminaries	CEST201	-	-	350$	14	560
			Total			**20**	**700**
	Fourth Semester						
1	Dissertation	CEST202	-	-	600$	20	800

$ **Internal**: 40% and **External**: 60%

*Swayam/NPTEL

Elective- 1

1. CEST111 Advanced Design of Steel Structures
2. CEST112 Numerical Methods for Structural Analysis
3. CEST113 Theory of Elasticity & Plasticity
4. CEST114 Wind Engineering

Elective-2

1. CEST115 Conceptual Design of Tall Structures
2. CEST116 Advanced Concrete Technology
3. CEST117 Advanced Construction Materials
4. CEST118 Theory of Plates and Shells

Elective -3

1. CEST119 Cold Formed Steel Design
2. CEST120 Finite Element Methods in Structural Engineering
3. CEST121 Mechanics of Composite Materials

Elective - 4

1. CEST122 Nonlinear Analysis of Frame Buildings
2. CEST123 Design of Prestressed Concrete Structures
3. CEST124 Foundation Design of Structures & Soil-structure Interaction
4. CEST125 Design of Bridge Structures

5. CEST 126 Structural Vibration Control

Institute Elective

1. CEST 127 Rehabilitation of Concrete Structures

2. CEST 128 Fire Resistant Design of Buildings

3. CEST 129 Design of Formwork systems

4. CEST 130 Continuum Mechanics

5. CECSXXX AI/ML Based Applications in Civil Engineering

CEST101: Structural Dynamics

L	T	P	C
3	1	-	4

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Comprehend the structural vibration, its characterization and develop simplest modelling approach for complex structure
CO2	Define structural damping and appropriate springs by considering different end conditions.
CO3	Apply suitable analysis approach for a special structure & its implementation.
CO4	Conceptualize vibrating body for free and forced vibration.
CO5	Analyse the behaviour of special structures and their adaptivity by considering different forced vibration.

2. Syllabus:

Topics	Hours
Introduction to Dynamics – Cause and effect of vibration, various types of pulses of vibration, single degree of freedom with and without damping, Free and forced vibration. Types of damping, viscous damping, critically damped system. Response of harmonic excitation, Dynamic equilibrium equation and solution, damping factor, Logarithmic decrement, Dynamic magnification factor, Eigen value, Problems on response of one degree of freedom system in harmonic loading.	**09**
Dynamics of beams – Resonance, dynamically sensitive structure – flexural vibration of uniform beams; Bernoulli – Euler Theorem, natural frequencies and mode shapes for five different end conditions of beams. Importance of first mode, and higher mode for various field problems. Dhumel integral, Blast load, Fourier analysis. Long span post-tension beam.	**08**
Introduction to Multi Degree freedom system – Idealization of actual problem, continuous mass v/s Lumped mass, natural frequencies and mode shapes. Introduction to modal analysis, free vibration analysis and it's important in seismic analysis. Approximate time period of different structures, Concept of response spectrum, Introduction of CQC and SRSS Method.	**09**
Modal analysis- Approximate formula for quick determination of natural frequencies and mode shape for beam, plate – square shape, circular shape with different end conditions at edges. Time period for elevated water tank and Bridge pier. Pipe supporting structure & Oil tank. I.S. code permissible limits of vibrations for machine and its foundation. Floor vibration in Industrial structure, Acceptance criteria for floor vibration, Fundamentals of Time history analysis & synthetic time history.	**09**
Introductions to Wind induced vibration- tall chimney, Von-karman Street formation, Strouhal number applications, vortex shedding frequency, Galloping of cable, Negative damping of cables. Numerical for Vortex shedding frequency.	**04**

[Total Theory Hours: 45, Tutorial Hours: 15]

Tutorial: The theoretical questions and numerical will be given as assignment to the students based on theory topics.

3. References:

1. Anderson, J. S., & Bratos-Anderson. (1987). Solving problems in vibrations. Harlow: Longman Scientific and Technical.
2. Edmund, B. (1994). Concrete structures in earthquake regions: Design and analysis (Concrete Design and Construction Series, pp. 105-108). Harlow: Longman Scientific & Technical.
3. Chopra, A. K. (2007). Dynamics of structures. Pearson Education India.
4. Clough, R. W., & Penzien, J. (1993). Dynamics of structures. New York: McGraw-Hill.
5. Paz, M. (2004). Structural dynamics (2nd ed.). Tata McGraw-Hill Education.
6. Meirovitch, L. (1986). Elements of vibration analysis (2nd ed.). Singapore: Tata McGraw-Hill.
7. Williams, M. (2016). Structural dynamics. CRC Press.
8. Jain, A. K. (2017). Dynamics of structure with MATLAB applications. Pearson.
9. Agarwal, P., & Shrikhande, M. (2006). Earthquake resistant design of structures. PH1 Learning Pvt Ltd.
10. Chopra, A. K. (2017). Dynamics of structures (Global edition, 5th ed.).
11. Gimsing, N. J., & Georgakis, C. T. (2012). Cable supported bridges: Concept and design. Wiley.
12. Srinivasulu, P., & Vaidyanathan, C. V. (2017). Handbook of machine foundations. McGraw-Hill Education.
13. Wilson, E. L. (2002). Three-dimensional static and dynamic analysis of structures. Computers and Structures, Inc.

CO-PO-PSO Mapping:

COs	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	2
CO2	3	3	2	2	2	1
CO3	2	1	3	3	2	2
CO[1]	3	2	1	3	3	2
CO5	3	3	3	3	3	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST102: Computer Methods of Analysis

L	T	P	C
3	1	-	4

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Comprehend fundamentals of computer-based analysis
CO2	Perform advanced structural analysis using stiffness method
CO3	Develops computer programs for analysis and design of structural elements using C++/MATLAB and Spreadsheet
CO4	Comprehend concepts of seismic design and perform linear and non-linear seismic analysis of RC buildings
CO5	Perform integrated analysis and design of RC building structures using structural analysis software(s) and comprehend concepts of seismic design

2. Syllabus:

Topic	Hours
Computer based Structural Analysis: Fundamentals Purpose and Types of Analysis – Kinematic and Statical determinacy – Determinacy of Plane Trusses – Pure Beams and Plane frames – Introduction to stiffness and flexibility methods of analysis	**06**
Stiffness Method for Linear Elastic Analysis: Analysis of plane and space trusses – Pure beams – Plane and space frames and grids using stiffness Method	**13**
Introduction to Computational tools for Structural Engineer: Spreadsheet tool for engineers - Programming with Excel/VBA Developing spreadsheet for design of structural elements. Introduction to Computer Programming in Structural Engineering using C++/MATLAB	**08**
Introduction to Seismic Analysis and Design Approaches: Concepts of linear and non-linear analysis procedures – Fundamentals of nonlinear static pushover analysis– Introduction to Direct Displacement Based Seismic design for RC buildings and concept of Performance Based Seismic Design of RC buildings.	**08**
Computer assisted Structural Analysis and Modeling: Modeling of structural elements like truss – beam – frame and grid using Structural design software – Developing structural models using graphical user interphase (GUI) – Understanding preprocessing and post processing phases for solving analysis problem – Solution errors and Model correctness – Analysis of building frames for gravity and lateral loading.	**10**

[Total Theory Hours: 45, Tutorial Hours: 15]

3. References:

1. Balfour, J. A. D. (1992). *Computer analysis of structural frameworks* (2nd ed.). Oxford, UK: Blackwell Scientific Publications.
2. Johnson, D. (2004). *Linear analysis of skeletal structures*. London, UK: Thomas Telford.
3. Paz, M., & Leigh, W. (2001). *Integrated matrix analysis of structures: Theory and computation*. Boston, MA: Kluwer Academic Publishers.
4. Hoit, M. (1995). *Computer assisted structural analysis and modelling*. NJ, USA: Prentice Hall.
5. Christy, C. T. (2006). *Engineering with spreadsheets: Structural engineering templates using Excel*. ASCE Press.
6. Davis, S. R. (1995). *Spreadsheets in structural design*. Longman.
7. Gilat, A., & Subramaniam, V. (2018). *Numerical methods for engineers and scientists: An introduction with applications using MATLAB*. Wiley.
8. Cirulis, M., & Wicks, P. (2015). *Structural analysis*. Thomas Telford Limited.

Tutorial: The theoretical questions and numerical will be given as assignment to the students based on theory topics.

4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	2	1	1	1
CO2	3	1	3	3	3	2
CO3	2	2	3	3	1	3
CO4	3	2	3	3	3	3
CO5	3	3	3	3	3	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST103: Experimental Stress Analysis

L	T	P	C
3	1	-	4

1. Course Outcomes (COs):

At the end of the course the students will be able to

CO1	Demonstrate state of the art measurement techniques of strain gauges and system of transducers to acquire force – deformation information.
CO2	Acquire the knowledge of photoelasticity fringe order to measure the principal stresses for 2Dobjects
CO3	Apply the brittle coating methods in analysis of cracking behavior.
CO4	Conduct the structural audit for applying appropriate various non-destructive tests.
CO5	Implement appropriate elastic failure theories in analysis and design of structures

2. Syllabus:

Topics	Hours
Introduction to stresses and strains, plane stress and plane strain problem, Cauchy's strain displacement relations, generalized Hook`s law dimensional analysis and theory and practice of direct and indirect model techniques.	02
Mechanical and electrical gauges, optical gauge, pneumatic and acoustical gauges, transverse sensitivity of strain gauges, temperature compensation of gauges, bonded and unbonded gauges, strain gauge rosettes	08
Load application and its measurement using gauges and use of deflection gauge for various structural systems/elements.	05
Brittle coating techniques and its applications to know the crack patterns qualitatively of structures for various to loadings. Moire and grid techniques for patterns of cracks.	07
Introduction to holography and interferometry, two- and three-dimensional photo-elasticity, photo elastic coatings, analogies, ideal properties of photo- elastic materials. Diffused light and lens polariscope, plane and circular polariscope. Application digital image correlation.	06
Introduction to non-destructive testing techniques like Rebound hammer method, Ultra pulse velocity test, core test etc. and its field applications. Interpretations of test results	06
Introduction to LVDT, X-rays technique, vibration measurement and application of shake table to get required desired data of various technical parameters. Application of DAQ system.	05
Theories of elastic failures like. Maximum principal stress theory, maximum principal strain theory, maximum shear stress theory, maximum strain energy theory and maximum shear strain energy theory etc., and its application in structural engineering.	06

[Total Theory Hours: 45, Tutorial Hours: 15]

3. References:

1. James W. Dally, William F. Riley, Experimental stress analysis, McGraw-Hill International Editions, New Delhi, Third edition, 2001.
2. L.S Srinath, M.R Raghavan, Lingaiah, G. Gargesha, B. Pant, Ramachandra, Experimental stress analysis, Pearson publication 2013.
3. U.C Jindal, Experimental stress Analysis, Pearson publication 2013.
4. Dove R C and Adams P H., "Experimental Stress Analysis and Motion Measurements", C E Merrill books, 1964.
5. Perry and Lisner "Strain Gauge Prime", Elsevier Publication, 1992.
6. K. Ramesh, Digital Photo elasticity – Advanced Techniques and Applications, Springer, 2000.

Tutorial: The theoretical questions and numerical will be given as assignment to the students based on theory topics.

4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	2	3	1	2	3
CO2	1	1	2	2	3	2
CO3	2	1	3	3	3	3
CO4	3	2	3	3	3	3
CO5	2	1	3	3	3	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST111: Advanced Design of Steel Structures

L	T	P	C
3	-	-	3

1. Course Outcome (COs):

At the end on the course the students will be able to:

CO1	Evaluate knowledge and proficiency to apply the provision of relevant IS code for design of various steel structures and behavior and its connection and limitation in design.
CO2	Design of beam-column and industrial building components for various need of infrastructure.
CO3	Enhance the knowledge for advanced design for torsion, fatigue and fire-resistant design.
CO4	Conceptualize the space structure like grid, dome, suspended roof structure and its approximate analysis method.
CO5	To make synthesis of planning and design of steel infrastructure and innovate space structure.

2. Syllabus:

Topics	Hours
• **Design of Beam-Column:** General behavior, second order movement in beam-column, elastic torsion buckling of beam-column, beam-column under biaxial loading, code design procedure, design of beam-column example, crane column, design of eccentrically loaded base plate	**10**
• **Design of Industrial Building Components:** Design of Gantry Girder, Plastic analysis and Design of rectangular portal frame and gable portal frame, design of steel tower, chimney, Pre-Engineering Building.	**09**
• **Design for Torsion:** Torsional loading in practice, behavior of member dure to torsion, approximate design procedure for torsion, torsional stiffening, torsional buckling, torsional deformation	**07**
• **Fatigue Resistance Design:** Different approaches to fatigue analysis, fatigue loading, general guidelines for fatigue resistance design – example	**07**
• **Fire Resistance design of steel structures**: Fire engineering design of steel structures, calculation approach, design curves and fire modals	**04**
• **Steel space structure:** Single and multilayer grids, braced domes, cable suspended roof structure, approximate method of analysis of space structures, overview of steel bridges.	**08**

[Total Theory Hours: 45]

3. References:

1. Subramaniam, N. (2009). Design of steel structures (3rd ed.). Oxford University Press.
2. Subramaniam, N. (1999). Principles of space structures (2nd ed.). Wheeler Publications.
3. Chandra, & Henlot, V. (2007). Design of steel structures: Vol. 2. Scientific Publication, Jodhpur.
4. Ram Chandran. (2008). Limit state design of steel structures. Standard Publication.
5. Ram Chandran. Design of steel structures: Vol. 2. Standard Publication.
6. Shiyekar, M. R. (2015). Limit state design of steel structures (3rd ed.).
7. Syal, I. C., & Singh, S. (Eds.). Design of steel structures (2nd ed.).
8. Syal, I. C., & Singh, S. (Eds.). Limit state design of steel structures (1st ed.).
9. Dugal, S. K. (2016). Limit state design of steel structures. McGraw Hill Education.
10. Shah, V. L., & Karve, S. R. (Eds.). (Year of publication). Limit state design of steel structures (4th ed.).

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4. CO-PO-PSO Mapping:

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	3	1	3
CO2	3	3	3	3	2	3
CO3	3	3	3	3	2	3
CO4	3	3	3	2	2	3
CO5	3	3	3	3	2	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST112: Numerical Methods of Structural Analysis

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Solve non-linear algebraic as well as simultaneous equations.
CO2	Derive numerical solution of ordinary and partial differential equations.
CO3	Apply integration method/s for structural analysis.
CO4	Evaluate solution of Eigen value problems and Fourier series for structural analysis.
CO5	Implement iterative and transformation methods in structural engineering.

2. Syllabus:

Topic	Hours
• **Solution of Non-linear Algebraic and Transcendental Equations:** Solution by graphical method, bisection method, Newton Raphson iterative method, Regula-Falsi method.	**07**
• **Errors:** Error analysis, types of errors, accuracy & precision, stability in numerical analysis	**05**
• **Solution of Simultaneous Equation:** Gauss elimination with Partial Pivoting, Gauss Jordan elimination method, LU Decomposition using clout's, Jacobi iterative – Gauss-Seidel iteration.	**07**
• **Elements of Matrix Algebra:** Solution of systems of linear equations, Eigen value problems. Applications to Structural Dynamic problems, stress problems, buckling of columns	**06**
• **Numerical Differentiation & Integration:** Solution of Ordinary and Partial Differential Equations, Euler's equation and other methods. Laplace equation - Properties of harmonic functions - Fourier transform methods for Laplace equation. Numerical Integration.	**10**
• **Finite difference method:** Finite difference technique, its applications to structural engineering problems.	**06**
• **Computer Algorithms:** Numerical solutions for different structural problems.	**04**

[Total Theory Hours: 45]

3. References:

1. Gilat, A., & Subramaniam, V. (2014). Numerical methods for engineers and scientists (3rd ed.). Wiley.
2. Burden, R. L., & Faires, J. D. (2011). Numerical analysis (9th ed.). Brooks/Cole.
3. Esfandiari, R. S. (2017). Numerical methods for engineers and scientists using MATLAB. CRC Press.
4. Hiestand, J. W. (2009). Numerical methods with VBA programming. Jones and Bartlett.
5. Kumar, K., & Kumar, R. (2018). Computer-based numerical and statistical techniques. CBS Publishers.

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4. CO-PO-PSO Mapping:

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	3	3	1	3
CO2	2	0	2	3	2	3
CO3	3	1	3	3	2	3
CO4	3	1	3	3	2	3
CO5	2	0	2	2	3	2

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST113: Theory of Elasticity & Plasticity

L	T	P	C
3	-	-	3

1. **Course Outcomes (COs):**

At the end of the course students will be able to:

CO1	Comprehend and apply principles of elasticity in sufficiently rigorous manner
CO2	Evaluate the response of the structure against three-dimensional stress state at a given point
CO3	Demonstrate the skill of problem formulations in elastic analysis
CO4	Analyze the solutions of 2D and 3D elementary problems in elasticity
CO5	Implement the concept of plasticity in a plastic analysis of structural forms

2. **Syllabus:**

Topics	Hours
• **Basic Concepts and Material Properties:** Force, Surfaces forces, Body forces, Statical and Kinematical indeterminacy, Macroscopic and microscopic properties, Isotropy, Homogeneity, Continuity, Uniaxial stress-strain relationship, Elasticity, Anelasticity, Work hardening, Ductility, Plasticity, Creep, Relaxation, Fatigue, Hysteresis, Bauschinger effect, Elastic, plastic and Viscous models.	**09**
• **Three-dimensional Elasticity:** Stress-tensor, Components of stress tensor, Equations of equilibrium in 2D and 3D Cartesian coordinates, Stresses on inclined plane, Transformation of stresses, Octahedral shear stresses, Stress invariants, Cauchy's stress quadric, Equilibrium equations in Polar coordinates, Strain-tensor, Components of strain tensor, Saint-Venant's Compatibility equations, Plane stress problem, Plane strain problem.	**11**
• **Formulations of Problems in Elasticity:** Stress-strain relation in 3D field, Generalised Hook's law, Relation between elastic constants, Displacement formulation or Navier's equations, Beltrami-Michell compatibility equations,	**09**
• **Application of Theory of Elasticity:** Airy's stress function, Solution of simply supported beams and cantilever beams subjected to different loadings by polynomials. Bending of prismatic bar, Saint-Venant's theory of torsion, Prandtl's theory of torsion, Membrane analogy.	**08**
• **Plasticity:** Principal stress state**,** Yield criteria and it's graphical representation, Plastic Stress-strain relations and diagrams, Flow rules, Strain hardening criteria. Plastic analysis of structural forms.	**08**

[Total Theory Hours: 45]

3. **References:**

1. Timoshenko, S. P., & Goodier, J. N. (2016). Theory of elasticity. New York, NY: McGraw Hill Book Co., Inc.
2. Volterra, E., & Gaines, J. H. (2012*).* Advanced strength of materials. New York, NY: Prentice Hall.
3. Venkatraman, B., & Patel, S. A. (2014). Structural mechanics with introduction to elasticity and plasticity*.* New York, NY: McGraw Hill.
4. Filonenko, M. (2013*).* Theory of elasticity. New York, NY: Dover Publications.
5. Wang, C. T. (2011). Applied elasticity. New York, NY: McGraw Hill.
6. Chakrabarty, J. (2016). Theory of plasticity. New York, NY: Elsevier.
7. Budynas, R. (2016). Advanced strength and applied stress analysis. New York, NY: Prime Publication.
8. Boresi, A. P., & Schmidt, R. J. (2016). Advanced mechanics of materials. New York, NY: Wiley.

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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	3
CO2	2	1	3	3	3	2
CO3	3	2	3	2	3	1
CO4	2	1	2	3	3	2
CO5	3	1	2	3	2	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST114: Wind Engineering

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Illustrate different characteristics of wind.
CO2	Determine dynamic effects of wind load on structures
CO3	Describe about wind tunnels and various available wind flow measuring techniques.
CO4	Design a structure for different types of wind induced loadings.
CO5	Estimate wind induced load according to IS – 875 codes.

2. Syllabus:

Topics	Hours
• **WIND CHARACTERISTICS:** Variation of wind velocity, atmospheric circulations – pressure gradient force, Coriolis force, frictionless wind balance, geo strophic flow, boundary layer. Extra ordinary winds – Foehn, Bora, Cyclones and Tornadoes etc.	**11**
• **STATIC AND DYNAMIC WIND EFFECTS:** Wind induced vibrations, flow around bluff bodies, along wind and across wind response, flutter, galloping, vortex shedding, locking, ovalling; analysis of dynamic wind loads, codal provisions – gust factor, dynamic response factor; wind load calculations as per IS 875 (part III); vibration control and structural monitoring; exposure to perturbation method, averaging techniques	**17**
• **WIND TUNNEL TESTING:** Open circuit and closed-circuit wind tunnels, rigid and aero elastic models, wind tunnel measurements and instruments along with site visit.	**11**

[Total Theory Hours: 45]

3. References:

1. Simiu, E., & Yeo, D. H. (2019). Wind effects on structures: Modern structural design for wind. New York, NY: John Wiley & Sons.
2. Simiu, E., & Scanlan, R. H. (1986). Wind effects on structures: An introduction to wind engineering. New York, NY: John Wiley & Sons.
3. Scruton, C. (1981). An introduction to wind effects on structures. Oxford, UK: Oxford University Press.
4. Sachs, P. (1978). Wind forces in engineering. Oxford, UK: Pergamon Press.
5. Lawson, T. V. (1980). Wind effects on buildings. London, UK: Applied Science Publishers.

4. CO-PO-PSO Mapping;

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	2
CO2	3	3	3	3	2	3
CO3	3	3	3	3	3	3
CO4	3	3	3	2	3	3
CO5	3	3	3	3	2	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST115: Conceptual Design of Tall Structures

L	T	P	C
3	-	-	3

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	Identify the criteria for design of various structural systems for tall buildings.
CO2	Evaluate loading for tall structures.
CO3	Preliminary design of high-rise structures
CO4	Analyze tube-in-tube construction and 3-dimensional analysis of shear core building.
CO5	Design of RC chimney and comprehend role of base isolation systems in tall structures.

2. **Syllabus:**

Topic	Hours
• **Principles of Planning of Tall Buildings** Need of tall buildings, Historical background of tall buildings, Elements of tall building project and involved professionals, Technological Planning, Mechanical systems, Fire rating, Local considerations, Structures elements, Shear Walls and their arrangement.	**04**
• **Loads on Tall Buildings – Materials for tall buildings** Gravity loads, Live loads, Fire Tender Loading, Wind loads and seismic loading, Discussion of relevant codes of practices and loading standards, detail discussion for code provisionsIS:16700 and other foreign codes, Measures to Reduce the Earthquake Response. Advanced materials for tall buildings	**08**
• **Behaviour of various Structural Systems** Types of structural systems for tall buildings, factors affecting growth, height and structural form. Gravity systems, lateral load resisting systems. High rise behavior with moment frame system, braced frames, In-filled frames, shear walls, coupled shear walls, wall-frames, tubular structures, outrigger - braced and hybrid mega systems. Different foundation systems for tall buildings.	**11**
• **Analysis of Tall Buildings (With and Without Shear Walls)** Approximate analysis for gravity loads, Lateral loads, Analysis of tube-in-tube constructional and 3-Dimensional analysis of shear core buildings, Stability, Stiffness and fatigue, Factor of safety and load factor.	**08**

- **Design of Tall Buildings** **06**
  Procedures of elastic design, Ultimate strength design and Limit state design of super structures including structural connections, soil structure interaction.

- **Design of RC chimney** **06**
  Introduction, dimensions of steel stacks, chimney lining, breech openings and access ladder, loading and load combinations, design considerations, stability consideration, design of base plate, design of foundation bolts, design of foundation.

- **Introduction to dampers** **02**
  Recent trends in seismic isolations, types of dampers, behaviour of friction pendulum system

[Total Theory Hours: 45]

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3. References:

1. Beedle, L. S. (1986). *Advances in tall buildings*. Delhi: CBS Publishers and Distributors.
2. Stafford Smith, B., & Coull, A. (2005). *Tall building structures: Analysis and design*. John Wiley & Sons, Inc.
3. Raju, N. K. (2001). *Advanced reinforced concrete design*. New Delhi: CBS Publishers.
4. Lin, T. Y., & Burry, D. S. (1988). *Structural concepts and systems for architects and engineers*. John Wiley.
5. Stafford Smith, B., & Coull, A. (1991). *Tall building structures: Analysis and design*. John Wiley & Sons.
6. Symposium on Tall Buildings with particular reference to Shear Wall Structures. (1996). University of Southampton.
7. Taranath, B. S. (2011). *Structural analysis and design of tall buildings*. McGraw Hill.
8. Schueller, W. (1977). *High rise building structures*. New York, NY: John Wiley & Sons.

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4. CO-PO-PSO Mapping:

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	3	3	3	3
CO2	3	0	2	2	1	2
CO3	3	2	3	3	3	3
CO4	3	2	3	3	2	3
CO5	2	2	3	3	2	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST116: Advanced Concrete Technology

L	T	P	C
3	-	-	3

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	Demonstrate cement hydration and its microstructure development.
CO2	Understand the concepts of special concrete and its mix design procedure.
CO3	Apply the Rheometers and corrosion analyzer systems for measurements in fresh and hardened concrete properties
CO4	Analyze the various durability related problems in reinforced concrete and its mitigation.
CO5	Create the relation of various concrete deterioration issues with microstructural features.

2. **Syllabus:**

Topics	Hours
• **HYDRATION OF CEMENT AND ADVANCECHARACTERIZATION TECHNIQUES**	**11**
Hydration of Cements and Microstructural development, Mineral additives, Chemical admixtures, Cracking and Volume stability, Deterioration processes, Special concretes, Advanced Characterization Techniques, Sustainability issues in concreting, Modelling properties	
• **ADVANCE MIX DESIGN AND RHEOLOGY OF CONCRETE**	**14**
Advanced Mixture Design, Design Philosophy - Particle Packing & Rheology - Discrete and Continuous approach, Packing density of powders and aggregates - Experimental tests and Models, Ternary Packing Diagram, Mixture Design of Self - Compacting Concrete (SCC); pervious concrete, Aerated concrete, Ultra high performance fibre reinforced concrete (UHFRC), Fresh Concrete Properties, Empirical test for SCC – Rheology, Basics, Parameters, Models, Rheometers, Rheology of Paste and concrete – Pumping, Setting, Curing, Plastic shrinkage, Strength Development, Maturity Method; Hardened Concrete Properties, Factors influencing strength, Interfacial Transition Zone, Stress strain relationship –Localization, End effects, Loading Conditions; Dimensional Stability, Creeping Shrinkage	
• **DURABILITY OF CONCRETE**	**10**
Durability, Permeability and Porosity, Chemical attack (Sulphate attack, Delayed Ettringite Formation, Chloride attack, Acid Attack, Sea Water attack, Carbonation, Freezing and Thawing, Alkali aggregate reaction, Alkali carbonate reaction Corrosion, Mode of action, failure, Tests& Protection methods	

- **REBAR CORROSION AND ITS EFFECTS** **10**

  Rebar Corrosion, Factors inducing rebar corrosion, electrochemical process, role of chloride in corrosion, role of carbon-di-oxide in corrosion, onset of corrosion, corrosion propagation, and service life prediction of concrete structures.

[Total Theory Hours: 45]

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3. References:

1. Neville, A. M. (2000). *Properties of concrete* (4th ed.). London: Pearson Education Limited.
2. Mehta, P. K., & Monteiro, P. J. M. (1999). *Concrete: Microstructures, properties, and materials* (Indian ed.). Chennai: Indian Concrete Institute.
3. Lea, F. M. (1970). *Chemistry of cement and concrete* (3rd ed.). London: Edward Arnold.
4. De Larrard, F. (1999). *Concrete mixture proportioning: A scientific approach*. London: E&FN Spon.
5. Aitcin, P. C. (1998). *High performance concrete*. London: E&FN Spon.
6. Santhakumar, A. R. (2007). *Concrete technology*. New Delhi: Oxford University Press.
7. Neville, A. M., & Brooks, J. J. (2012). *Concrete technology*. London: Pearson Education Ltd.
8. Aligizaki, K. K. (2005). *Pore structure of cement-based materials: Testing, interpretation and requirements*. CRC Press.

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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	2
CO2	3	3	3	3	2	3
CO3	3	2	3	3	2	3
CO4	3	3	2	2	3	3
CO5	3	2	3	3	2	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST117: Advanced Construction Materials

L	T	P	C
3	**-**	**-**	**3**

1. Course Outcomes (COs):

At the end of the course, the students can able to

CO1	Demonstrate the fundamentals of material science
CO2	Understand the properties of materials
CO3	Analyses the properties of sustainable material
CO4	Apply quality aspects in concrete construction
CO5	Create the special and eco-friendly concrete

2. Syllabus:

Topics	Hours
• **Material Science** Classification, Standardization, Codification and Variety. Details of Micro Structure of Different construction Materials, Different effects on materials of construction	08
• **Properties of Materials** Environmental Influences, Thermal effects Effect of Chemicals, Fire resistance, Corrosion and Oxidation, Radiation. Properties of fresh & hardened concrete. Shrinkage & creep of concrete.	08
• **Sustainable Materials** Introduction, sustainability and goals, current situation, earth's natural system, carbon cycle, role of construction materials, CO2 from fossil fuel vis-à-vis cement and other construction materials. Construction material and indoor air quality. Energy for production, transportation and erection, Estimation methodology, Computation of embodied energy for building. Primary energy and Energy Concepts	12
• **Advance Concrete** High volume fly ash concrete, geo-polymer concrete and their embodied energy content against OPC concrete. Aggregate resource depletion, recycled aggregate from demolition etc. role of quality control and admixtures in sustainability. Durability of construction material and life cycle sustainability.	09
• **Other Material** Polymer materials, Thermo - Plastic, Polymer Concrete, Composite, materials, Ferro cement, Ferroconcrete, Building materials from Agricultural, & Industrial wastes, M Sand, Glass, Cladding, Light Weight Concrete	08

[Total Theory Hours: 45]

3. References:

1. Wu, C. H. (2006). Advanced civil infrastructure materials (1st ed.). Woodhead Publishing Limited.
2. Newman, J., & Choo, B. S. (2003). Advanced concrete technology: Processes (1st ed.). Elsevier.
3. Kubba, S. (2010). LEED practices, certification, and accreditation handbook (1st ed.). Elsevier.
4. Ministry of Power. (2007). Energy conservation building code: Revised version. Bureau of Energy Efficiency.
5. Neville, A. M. (1973). Properties of concrete (3rd ed.). Bath, UK: Pitman Publishing Company.
6. Shetty, M. S. (1986). Concrete technology: Theory and practice (2nd ed.). New Delhi: S. Chand & Company.
7. Gambhir, M. L. (1986*).* Concrete technology (1st ed.). New Delhi: Tata McGraw Hill Company.
8. Shantha Kumar. (2006). Concrete technology. New Delhi: Tata McGraw Hill Co.
9. Troxell, G. E., & Davis, H. E. (1998). Composition and properties of concrete. McGraw Hill.

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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	2	3	1	3
CO2	3	2	2	3	2	3
CO3	3	3	3	3	2	3
CO4	3	2	3	2	2	3
CO5	2	3	3	3	2	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST118: Theory of Plates and Shells

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the concepts of bending and membrane theory
CO2	Develop analytical methods of solution for thin plates and shells
CO3	Predict the behaviour of plates and shells under applied loading
CO4	Identify solution to complex problems using numerical techniques and tools
CO5	Demonstrate the knowledge and skills obtained to challenges in practice

2. Syllabus:

Topics	Hours
• **Plates:** Introduction, classification, classical plate theory: Kirchhoff's theory for thin plates, differential equation of equilibrium of rectangular plates for bending in one and two directions, plates with various boundary conditions, geometrics and loading, classical solution of plate equations: the Navier solution and the Levy solutions, differential equation of equilibrium of circular plates for bending, solutions for circular plates under axi-symmetrical loading, energy method, numerical method: finite difference method, buckling of plates, vibration of plates: free vibrations, application to design of rectangular water tank.	**24**
• **Shells:** Introduction, classification, definitions, membrane theory of cylindrical shells, bending theory of cylindrical shells subjected to axi-symmetrical loading, beam theory of cylindrical shells, introduction to shells of double curvature, membrane theory of shells of revolution, application to design of circular water tank.	**21**

[Total Theory Hours: 45]

3. References:

1. Ramaswamy, G. S. (2005). Design and construction of concrete shell roofs. CBS Publishers.
2. Szilard, R. (2004). Theories and applications of plate analysis: Classical, numerical, and engineering methods. John Wiley & Sons.
3. Timoshenko, S., & Krieger, W. S. (2017). Theory of plates and shells. New York, NY: McGraw-Hill.
4. Shames, I. H., & Dym, C. L. (2017). Energy and finite element methods in structural mechanics. New York, NY: Taylor & Francis.
5. Gould, P. L. (2012). Analysis of shells and plates. Springer Science & Business Media.

4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST104: Structural Engineering Laboratory

L	T	P	C
-	-	4	2

1. Course Outcomes (COs):

At the end on the course the students will be able to:

CO1	Explore various lab equipment and instruments
CO2	Demonstrate the static behavior of structural elements
CO3	Demonstrate the dynamic behavior of engineering systems
CO4	Apply the concepts to solve the real time problems
CO5	Provide solutions to various engineering applications

2. Syllabus:

- Stress-strain behaviour of Mild Steel using Mechanical Gauge (Huggen burger extensometer)
- Modulus of Elasticity of Concrete using Compressometer
- Behaviour of RC Beams under Flexure (under- and over-reinforced)
- Behaviour of RC Beams under Shear
- Behaviour of RC Beams under Torsion
- Behaviour of RC Short Reinforced Columns under Axial Compression
- Vibration of single span beams with Mode Shapes
  (a) One end fixed and other end free (Cantilever)
  (b) One end fixed and other end hinged
  (c) Both ends fixed
- Torsional Vibration of Fixed-free Three Rotor System
- Vibration Absorber (Rectilinear)
- Damped Torsional Vibration to determine Coefficient of Damping
- Linear Shake Table Experiment
- Single Point Vibration Measurement of Structure
- Non-destructive Testing
- Corrosion Rate Measurement by using Corrosion Analyser
- Rectangular Plates with Holes under In-plane Loads

[Total Practical Hours: 60]

3. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	2
CO2	3	2	3	2	3	3
CO3	3	2	3	2	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST105: Advanced Design of Concrete Structures

L	T	P	C
3	1	-	4

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Extend knowledge and proficiency to apply the provisions of relevant IS-code for design of appropriate type of combined shallow foundations with detailed report and drawings.
CO2	Design deep foundations like pile and pile caps for various soil and loading conditions with detailed sketch.
CO3	Enhance knowledge for the advanced design concepts of flat slab
CO4	Learn complete design procedures for retaining walls, shear walls and grid floors
CO5	Calculate serviceability criteria for deflection and crack width.

2. Syllabus:

Topics	Hours
• **Design of combined shallow foundations**: Design of combined footings on boundary of plot, Strip footing, Strap footing, Raft foundation with IS provisions.	**10**
• **Design of deep foundations:** Pile foundation, Soil design and structural **design** of pile. Load carrying capacity of pile in sandy soil, clayey soil. Pile resting on rock. Design of group of piles. Design of pile cap	**07**
• **Design of RCC Flat slabs:** Merits and Demerits of flat slabs as compared to **other** floor systems. Drop and capital in flat slab. Direct design method and equivalent frame method. IS provisions related to flat slab. Effect of opening in design of flat slab.	**07**
• **Design of retaining walls:** Different components of cantilever and **counterfort** retaining wall with and without surcharge. Check for overturning and check for sliding. Provision of key wall.	**06**
• **Design of shear-wall:** Classification of shear walls, loads in shear wall, design of rectangular and flanged shear walls, coupled shear wall	**06**
• **Introduction and Analysis of Grid floors for large span structures.**	**06**
• **Serviceability criteria of crack width:** Calculation of deflection due to load, shrinkage & creep and calculation of crack width as per IS code.	**03**

[Total Theory Hours: 45, Tutorial Hours: 15]

3. **References:**

1. Shah, H. J. (2020). Reinforced concrete (Vol. I & II). Charotar Publishing House.
2. Raju, K. (2017). Advanced reinforced concrete design. CBS Publishers and Distributors Pvt. Ltd.
3. Sinha, S. N. (2014). Reinforced concrete design. Tata McGraw Hill Education.
4. Varghese, P. C. (2009). Design of reinforced concrete foundations. Prentice-Hall of India Pvt. Ltd.
5. Sharma, H. K., & Agrawal, G. L. (2001). Earthquake resistant building construction. ABD Publishers.
6. Varghese, P. C. (2011). Advanced reinforced concrete design. Prentice-Hall of India Pvt. Ltd.
7. IS:456 -2000. Code of practice for plain and reinforced concrete
8. IS:875 (Part 1 to 5). Code of practice for design loads (other than earthquake) for building and structures
9. IS:1893-2016 (Part-1). Criteria for earthquake resistant design of structures: general provisions and buildings.
10. IS:13920-2016. Ductile detailing of reinforced concrete structures subjected to seismic forces — code of practice.
11. SP:16. Design aid for reinforced concrete
12. SP:34. Handbook on concrete reinforcement and detailing.

Tutorial: The theoretical questions and numerical will be given as assignment to the students based on theory topics.

4. **CO-PO-PSO Mapping:**

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	3
CO2	3	3	3	3	2	3
CO3	3	3	3	3	2	3
CO4	3	3	3	2	2	3
CO5	3	3	3	3	2	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CE ST106: Earthquake Resistant Design of Structures

L	T	P	C
3	1	-	4

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe the principles of engineering seismology
CO2	Calculate the lateral load distribution on RCC Building.
CO3	Categorize the irregularities in buildings as per the clauses given in Codal Provisions.
CO4	Analyze and Design earthquake resistant reinforced concrete buildings and water tank as per the Codal provision.
CO5	Deduce the concept of base-isolation and dampers in building.

2. Syllabus:

Topics	Hours
Seismic Hazard Assessment: Seismic Hazard Assessment: Engineering Seismology, Definitions, Introduction to Seismic hazard, Earthquake phenomenon, Seismo-tectonics and seismic zoning of India-Earthquake monitoring and seismic instrumentation, Characteristics of strong Earthquake motion, Estimation of earthquake parameter, Micro zonation	**11**
Lateral load on Buildings: Lateral load on Buildings: Rigid diaphragm effect, Centre of mass and centre of stiffness, Torsional coupled and uncoupled systems, Distribution of lateral force for One storey and Multiple stories building.	**11**
Structural Configuration of Buildings: Structural Configuration for earthquake resistant design, Concept of plan irregularities, soft storey, Torsion in buildings. Design provisions for these in IS-1893. The effect of infill masonry walls on frames. Modelling concepts of infill masonry walls. Behavior of masonry building during earthquake, failure patterns.	**11**
Concept of Earthquake Resistance Design: Concept of earthquake resistance design: Review of latest Indian seismic code IS 1893 (Part-1 and 2) and IS 4326 Provisions for buildings, Earthquake design philosophy, Analysis by seismic coefficient and response spectrum methods, IS 13920 Provisions for ductile detailing of RC building – beams, columns and joints. Earthquake analysis of elevated water tank, Model provisions for ground supported and elevated water tanks, impulsive and convective mass of water, Calculation of time period, Base shear, Base moments, Hydrodynamic pressure and sloshing wave height.	**12**

[Total Theory Hours: 45, Tutorial Hours: 15]

3. References:

1. Agrawal, P., & Shrinkhande, M. (2004). Earthquake resistant design of structures (1st ed.). New Delhi: Prentice Hall of India Pvt. Ltd.
2. Pauley, T., & Priestley, M. J. N. (1992). Seismic design of reinforced concrete and masonry buildings. John Wiley & Sons.
3. Park, R., & Paulay, T. (1975). Reinforced concrete structures. John Wiley & Sons.
4. Ghose, S. K. (n.d.). Earthquake resistance design of concrete structures. SDCPL – R&D Center, New Mumbai.
5. Dowrick, D. J. (2009). Earthquake resistant design and risk reduction (2nd ed.). John Wiley & Sons.
6. Kappos, A., & Penelis, G. G. (2014). Earthquake resistant concrete structures (1st ed.). CRC Press.
7. Llunji, M. (2016). Seismic architecture: The architecture of earthquake resistant structures (International ed.).

Tutorial: The theoretical questions and numerical will be given as assignment to the students based on theory topics.

4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PS03
CO1	03	01	02	03	01	03
CO2	02	01	03	03	02	02
CO3	03	00	03	02	03	03
CO4	03	01	03	03	02	03
CO5	02	00	03	02	02	03

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST119: Cold Formed Steel Design

L	T	P	C
3	-	-	3

1.Course Outcome (COs):

At the end of the course the students will be able to:

CO1	Have the knowledge of cold formed steel and general uses and approach to design, structural behavior
CO2	Design of cold formed compression, flexural members for various needs.
CO3	Get the knowledge of connection for cold form steel members.
CO4	Enhance the knowledge for roof structure, light frame construction using cold form steel.
CO5	Learn the complete design and uses of cold formed steel in field

2. Syllabus:

Topic	Hours
Introduction: Types of cold formed steel section, design specification, general design consideration design basis, serviceability material used in cold formed steel construction.	**05**
Strength of thin elements and design criteria: Structural behaviour **of** compression elements and effective width design criteria, Direct strength method and consideration of local and distorted buckling, perforated elements and member plate buckling of structural shape.	**09**
Flexural members: bending strength and deflection, design of beam **web**, bracing requirement of beam, torsional analysis of beam- example.	**09**
Compression members: Column buckling, distorted buckling **strength** of compression members, Built-up compression member- Design example.	**08**
Connections: Type of connector welded connection, bolted	**06**
Roof structure: Steel shear diaphragms, shell roof structure, corrugated sheets.	**06**
Light frame construction: Framing standards, design bridges	02

[Total Theory Hours: 45]

3. References:

1. Wel-wenyy, R. A., & La bouble. (2019*).* Cold formed steel design (5th ed.).
2. Punmia, B. C. (2018). Design of steel structures.
3. Chandra, & Henlot, V. (2007*).* Design of steel structures: Vol. 2. Scientific Publication, Jodhpur.

4. Ram Chandran. (2008). Limit state design of steel structures. Standard Publication.
5. Ram Chandran. Design of steel structures: Vol. 2. Standard Publication.
6. Shiyekar, M. R. (2015). Limit state design of steel structures (3rd ed.).
7. Dr. I. C Syal and Satinder Singh – "Design of Steel Structures 2nd edition"
8. Dr. I. C Syal and Satinder Singh – "Limit State design of steel structure 1st edition"
9. Dugal, S. K. (2016). Limit state design of steel structures. McGraw Hill Publication.
10. Shah, V. L., & Karle, S. R. (Eds.). (Year of publication). Limit state design of steel structures (4th ed.).

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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	3
CO2	3	3	3	3	2	3
CO3	3	3	3	3	2	3
CO4	3	3	3	2	2	3
CO5	3	3	3	3	2	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST120: Finite Element Methods in Structural Engineering

L	T	P	C
3	1	-	4

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Illustrate the basic concepts of finite element (FE) analysis.
CO2	Identify and select the suitable element and mesh configuration to obtain converged solution.
CO3	Develop the element characteristic equation and generation of global equation
CO4	Create 1D, 2D and 3D FE models of practical problems
CO5	Apply the FE analysis on actual problem to determine induced displacements, forces, stresses and strains

2. Syllabus:

Topics	Hours
• **Introduction:** Matrix algebra, Fundamentals of continuum mechanics, Stresses, displacements and strains in solids, Constitutive relations and models. Differential equations in solid and soil mechanics. Analytical and Numerical Solutions: Closed form solutions, why study numerical analysis? Numerical methods - FDM, FEM and DEM. Introduction to FEM	**06**
• **Formulations in FEM:** Direct stiffness-matrix method, Potential energy method, Rayleigh-Ritz method, Weighted Residual method: Galerkin's Method, Errors in FEM.	**06**
• **One-and Two-Dimensional Problems:** Plane stress and strain, Interpolation functions, Shape functions (Lagrangian/Natural), Isoperimetric elements – 1D and 2D, Numerical integration. Infinite elements, Lagrangian Element, Joint elements, Serendipity elements, Transition elements, Assembly and Solution techniques, Convergence requirements, Patch test.	**10**
• **Axisymmetric Problems:** Formulation and Examples.	**06**
• **Three-Dimensional Problems, Constitutive Modelling:** Formulation and Examples, Elastic, Elastic-plastic and constitutive models for structural engineering applications.	**05**
• **FE Analysis in Structural Engineering:** Preprocessing and Post processing, Applications: Heat transfer and mass transport, Thermal stresses, Vibration and Buckling (the eigenvalue problem), Linear and Non-Linear Analysis of Trusses, Beams, Frames, Shells, and plates with dynamic, material and geometric nonlinearities considerations.	**12**

[Total Theory Hours: 45, Tutorial Hours: 15]

Tutorial: The theoretical questions and numerical will be given as assignment to the students based on theory topics.

3. References:

1. Bathe, K.J. (2007). Finite Element Procedures. New Delhi: Prentice-Hall of India Pvt. Ltd.
2. Chandrupatla, T.R., & Belegundu, A.D. (2011). Introduction to Finite Elements in Engineering. New Jersey: Pearson Education.
3. Cook, R.D., Malkus, D.S., Plesha, M.E., & Witt, R.J. (2002). Concepts and Applications of Finite Element Analysis. New York: John Wiley & Sons.
4. Dawe, D.J. (1984). Matrix and Finite Element Displacement Analysis of Structures. Oxford: Clarendon Press.
5. Desai, Y.M., Eldho, T.I., & Shah, A.H. (2011). Finite Element Method with Applications in Engineering. New Delhi: Pearson Education India.
6. Hutton, D.V. (2004). Fundamentals of Finite Element Analysis. New Delhi: McGraw-Hill.
7. Krishnamoorthy, C.S. (2007). Finite Element Analysis. New Delhi: Tata McGraw-Hill Publishing Company Ltd.
8. Logan, D.L. (2007). A First Course in the Finite Element Method. New Delhi: Cengage-Learning.
9. Reddy, J.N. (2005). An Introduction to the Finite Element Method. New Delhi: McGraw-Hill.
10. Seshu, P. (2008). Textbook of Finite Element Analysis. New Delhi: PHI Learning Pvt. Ltd.
11. Zienkiewicz, O.C., Taylor, R.L., & Zhu, J.Z. (2014). The Finite Element Method Its Basis and Fundamentals. Amsterdam: Elsevier.

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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	1	-	1	1
CO2	2	1	2	1	1	1
CO3	2	2	2	1	2	2
CO4	3	3	3	2	3	3
CO5	3	3	3	3	3	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST121: Mechanics of Composite Materials

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to

CO1	Understand the phenomenon of composite material and learn the characteristics of different composite materials
CO2	Analyze problem on macro mechanical and micromechanical behavior of a lamina.
CO3	Learn transformation matrix and laminate constitutive equations for isotropic, anisotropic and orthotropic laminates
CO4	Evaluate the lamina properties from laminate tests and understand their behaviour
CO5	Solve problem on free vibration, bending and buckling of laminated plates and unidirectional beams.

2. Syllabus:

Topics	Hours
Introduction to Composite Materials Constituents, Applications Definition – Need – General Characteristics, Applications.	**05**
Fibers – Glass, Carbon, Ceramic and Aramid fibers. Matrices – Polymer, Graphite, Ceramic and Metal Matrices – Characteristics of fibers and matrices.	**07**
Macromechanical and Micromechanical behavior of a lamina, Lamina Constitutive Equations.	**05**
Generalized Hooke's Law, Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix, Typical Commercial material properties, Rule of Mixtures.	**04**
Generally Orthotropic Lamina –Transformation Matrix, Transformed Stiffness	**02**
Macromechanical behavior of a laminate, Definition of stress and Moment Resultants, Strain Displacement relations.	**02**
Basic Assumptions of Laminated anisotropic plates, Laminate Constitutive Equations – Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli.	**04**
Evaluation of Lamina Properties from Laminate Tests, Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates, Maximum Stress and Strain Criteria, Von-Misses Yield criterion for Isotropic Materials.	**06**

Generalized Hill's Criterion for Anisotropic materials. Tsai-Hill's Failure Criterion for Composites. Tensor Polynomial Failure criterion. Prediction of laminate Failure Equilibrium Equations of Motion, Energy Formulations. Static Bending Analysis, Buckling Analysis. Free Vibrations – Natural Frequencies Modification of Hooke's Law due to thermal properties - Modification of Laminate Constitutive Equations.	**06**
Orthotropic Lamina - special Laminate Configurations – Unidirectional, Thermally Quasi-Isotropic Laminates, Delamination, Matrix Cracking, and Durability, Interlaminar stresses, Edge effects, Fatigue and fracture, Environmental effects,	**04**

[Total Theory Hours: 45]

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3. References:

1. Jones, R.M. (1985). Mechanics of Composite Materials. Tokyo: McGraw-Hill, Kogakusha Ltd.
2. Agarwal, B.D., & Broutman, L.J. (1995). Analysis and Performance of Fibre Composites. New York: John Wiley & Sons, Inc.
3. Hyer, M.W. (1998). Stress Analysis of Fiber-Reinforced Composite Materials. McGraw-Hill.
4. Kaw, A.K. (2006). Mechanics of Composite Materials (2nd ed.). CRC Press.
5. Daniel, I.M., & Ishai, O. (2013). Engineering Mechanics of Composite Materials. Oxford University Press.
6. Hetnarski, R.B., & Eslami, M.R. (2019). Thermal Stresses-Advanced Theory and Application. Switzerland: Springer.
7. Carrera, E., Fazzolari, F.A., & Cinefra, M. (2016). Thermal Stress Analysis of Composite Beams, Plates and Shells: Computational Modelling and Applications. Academic Press.

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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	2	2
CO2	3	3	2	2	1	3
CO3	2	3	3	3	2	3
CO4	3	3	2	2	1	2
CO5	3	2	3	3	2	2

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST122: Nonlinear Analysis of Frame Buildings

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Evaluate the elastic behaviour of moment-resisting frame buildings using classical structural analysis
CO2	Detect the sources of geometric nonlinearity in frame buildings
CO3	Identify the sources of material nonlinearity in frame buildings
CO4	Predict the inelastic behaviour of moment-resisting frame buildings using nonlinear static analysis
CO5	Assess the performance of moment-resisting frame buildings using nonlinear static analysis

2. Syllabus:

Topics	Hours
• **Introduction to Frame Buildings and Nonlinear Actions:** Structural Systems and Moment-Resisting Frames, Structural Actions, Sources of Nonlinearities in Frame Buildings	**03**
• **Classical Structural Analysis:** Basis of Structural Analysis: Modelling, Loading and Response; Principles of Structural Mechanics; Static and Kinematic Indeterminacy; Coordinate Frames; Slope Deflection Method, General Procedure for Linear Elastic Static Analysis, Special issues (Real Hinges, Specified Deformation at Supports, Flexible Restraints at Supports)	**05**
• **Geometric Nonlinear Static Analysis:** Effect of Axial Deformation on Bending, Effect of Bending on Axial Stiffness, Stability and Buckling, Solving Nonlinear Systems, General Procedure for Nonlinear Elastic Static Analysis, Special Issues Small Strain) and Large Deformation; Effective Length of Frame Members)	**13**
• **Material Nonlinear Static Analysis:** Stress-Strain Relations, Plastic Actions (Lumped Plasticity, Distributed Plasticity), Inelasticity in Frames: Lumped Plasticity Approach, General Procedure for Nonlinear Inelastic Static Analysis	**13**
• **Combined Geometric-Material Nonlinear Static Analysis:** General Procedure for Nonlinear Static Analysis including Geometric and Material Nonlinearity; Performance assessment of Frame Buildings using Nonlinear Static Analysis (using ATC 40, FEMA 356 and FEMA 440); Nonlinear Static Analysis of Frame Buildings using commercial softwares like SAP 2000 or Perform 3D**.**	**11**

[Total Theory Hours: 45]

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3. References:

1. Yang, Y.B., & Kuo, S.R. (1994). Theory and Analysis of Nonlinear Framed Structures. New Delhi: Prentice Hall India Private Limited.
2. Satyamoorthy, M. (2017). Nonlinear Analysis of Structures. Boca Raton, FL: CRC Press.
3. Hibbeler, R.C. (2017). Structural Analysis (8th ed.). New Jersey: Prentice Hall.
4. Levy, R., & Spillers, W.R. (2010). Analysis of Geometrically Nonlinear Structures. New York: Chapman & Hall.
5. Kassimali, A. (2011). Matrix Analysis of Structures. USA: Brooks/Cole Publishing Company.
6. Menon, D. (2009). Advanced Structural Analysis. New Delhi: Narosa Publishing House.
7. Nelson, J.K., & McCormac, J.C. (2003). Structural Analysis: Using Classical and Matrix Approaches. New York: John Wiley and Sons Inc.
8. Ghali, A., & Neville, A.M. (2017). Structural Analysis – A Unified Classical and Matrix Approach. London, UK: E&FN Spon.
9. Weaver, W., & Gere, J.M. (2018). Matrix Analysis of Framed Structures. New Delhi: CBS Publishers and Distributors.
10. Kanchi, M.B. (2016). Matrix Methods of Structural Analysis. New Delhi: Wiley Eastern Limited.
11. McGuire, W., Gallagher, R.H., & Ziemian, R.D. (2015). Matrix Structural Analysis (2nd ed.). New York, NY: John Wiley and Sons.

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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	2
CO2	2	2	3	3	3	2
CO3	2	2	3	3	3	2
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST123: Design of Prestressed Concrete Structures

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Demonstrate the basic knowledge of theory and practice of prestressing of structural elements.
CO2	Apply different techniques of prestressing such as pre tensioning, post tensioning, and other means of pre stressings.
CO3	Analyze the limit state design criteria for prestressed concrete members and quantify the prestress losses as well as deflections.
CO4	Design pretension and post tensioned Flexural member and statically indeterminate prestressed structures.
CO5	Develop various types of concrete structures either by linear or circumferential prestressing

2. Syllabus:

Topics	Hours
INTRODUCTION TO PRESTRESSED CONCRETE AND MATERIALS: Introduction: -Concept of Prestressing, Advantages of Prestressing, Materials for prestressed concrete.	**04**
ANALYSIS OF PRESTRESSAND LOSSES OF PRESTRESS: Different Prestressing System, Analysis of prestress and bending stresses various losses of prestress, Deflection of prestressed concrete member	**05**
FLEXURAL STRENGTH OF PRESTRESSED CONCRETE MEMBERS: Flexural strength of prestressed concrete members, Transfer of prestress in pretensioned members.	**07**
ANCHORAGE ZONE STRESSES: Anchorage zone stresses in post tensioned members- Limit state design criteria for Prestressed concrete members.	**06**
DESIGN OF INDETERMINATE PRESTRESSED STRUCTURES: Design of prestressed concrete sections – Design of pretension and post tensioned Flexural member statically indeterminate Prestressed Structures	**06**
PRESTRESSED CONCRETE PIPES AND TANKS: Prestressed concrete pipes and tanks, Prestressed concrete slabs and grid floors	**07**
DESIGN OF PRESTRESSED CONCRETE STRUCTURES: Prestressed concrete poles, pipes, sleepers, pressure vessels and pavements – Prestressed concrete Bridges	**10**

[Total Theory Hours: 45]

3. **References:**

1. Krishna Raju, N. (2018). Prestressed Concrete (6th ed.). New Delhi: Tata McGraw Hill.
2. Dayaratnam, P. (2005). Prestressed Concrete Structures. New Delhi: Oxford & IBH Publication.
3. Pandit, G.S., & Gupta, S.P. (2012). Prestressed Concrete. New Delhi: CBS Publishers and Distributers Pvt. Ltd.
4. Lin, T.Y., & Burns, N.H. (2013). Design of Prestressed Concrete Structures (3rd ed.). New Delhi: Wiley India Pvt. Ltd.
5. Leonhardt, F. (2000). Prestressed Concrete – Design & Construction. Munich, Germany: Wilhelm Ernst and Sohn.
6. Aalami, B. (2021). Post Tensioning Concept; Design; Construction. PT Structures.
7. Guyon, Y. (2003). Prestressed Concrete (Vol. I and II). Pune: Asia Publication.
8. Bureau of Indian Standards. (2012). IS 1343:2012, Code of Practice for Prestressed Concrete. New Delhi: Bureau of Indian Standards.
9. Bureau of Indian Standards. (2008). IS 3370- Part 4, Indian Standard Code of Practice for Concrete Structures for the Storage of Liquid- Design Tables. New Delhi: Bureau of Indian Standards.

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4. **CO-PO-PSO Mapping:**

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	1	2	3
CO2	1	2	2	2	3	2
CO3	3	3	3	3	3	3
CO4	2	3	3	3	3	3
CO5	3	3	3	3	3	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST 124: Foundation Design of Structures & Soil-Structure Interaction

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Interpret laboratory and field-testing results for foundation design.
CO2	Comprehend soil investigation reports and suggest the suitable type of foundation.
CO3	Design shallow and deep foundation, various machine foundations
CO4	Evaluate bearing capacity and settlement of shallow and deep foundations using various approaches
CO5	Apply the acquired knowledge for the design of special foundation.

2. Syllabus: Hours

Topic	Hours
• **Soil Properties, Soil Exploration and Soil Improvement Techniques:** Soil properties and its applications, Laboratory testing, Soil exploration techniques – comparisons, sounding tests, Geophysical methods, Sampling, Interpretation of Laboratory & field Testing, liquefaction, Quick Sand Condition, Introduction to Injection and grouting, Prefabricated vertical drain, Basic of vibroflotation, stone column.	09
• **Introduction to Shallow Foundation and Earth Retaining Structures:** Soil Investigation Reports study, bearing capacity of soil, classification and designing of Shallow Foundation, Settlement of Foundations, Foundation on collapsible and expansive soil, Earth Reinforcement, RE wall, Gabion wall concept, Rock Anchoring, Diaphragm technique, Diaphragm wall with anchor, Box Pushing, Cantilever Retaining wall & Counterfort Retaining wall, Drainage for Retaining wall, Bridge Abutment wall.	07
• **Introduction Deep Foundation:** Caisson foundation, Cellular cofferdam, Braced-cut and Drainage	03
• **Machine Foundation:** Types of machine foundation, General criteria, Theory of vibration, Single degree freedom system, Soil dynamic parameters, Block type machine foundation (Checking of resonance and permissible amplitude), vibration isolation techniques	08
• **Pile Foundation:** Types of piles, Factors affecting choice of types of piles, Pile load test, Load carrying capacity of piles, Pile group, Group efficiency, Lateral resistance of piles, settlement of piles, Negative skin friction	08
• **Special Foundations:** Classification of Foundation, Special foundations, Raft foundation, types of rafts, Beams on elastic foundation, footing subjected to	10

moments, Footing subjected to tension, Geotextiles, various methods of foundation design, Technological consideration in Geotechnical Engineering. Idealization of soil-structure interaction. Concept of Non-linear Winkler foundation

[Total Theory Hours: 45]

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3. References:

1. Murthy, V.N.S. (2007). Advanced Foundation Engineering. New Delhi: CBS Publishers and Distributors.
2. Punmia, B.C. (2012). Soil Mechanics and Foundations. New Delhi: Laxmi Publication.
3. Purushothama Raj, P. (2020). Ground Improvement Techniques. New Delhi: Laxmi Publication.
4. Bowles, J.E. (1988). Foundation Analysis & Design. New York: McGraw Hill Inc.
5. Brooks, H. (2018). Basics of Retaining Wall Design. Newport Beach, CA: HBA Publication.
6. Das, B.M. (2011). Principles of Foundation Engineering. Boston: PWS Publishing Co.

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4. CO-PO-PSO Mapping:

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	3	3	1	3
CO2	3	3	3	3	3	3
CO3	3	2	3	3	2	3
CO4	3	2	2	3	3	2
CO5	3	1	3	3	3	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST 125: Design of Bridge Structures

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Demonstrate state-of-the-art practice including fundamental knowledge of relevant code specifications in bridge engineering.
CO2	Analyze and design the bridge components such as superstructures, substructures, bearings and deck joints.
CO3	Design short and medium span bridges using existing code of practice by taking into account the structural strength, serviceability and durability aspects.
CO4	Evaluate the special features of Prestressed concrete bridges, Balanced cantilever and Cable stayed bridges.
CO5	Analyze the bridge structures by various methods.

2. Syllabus:

Topics	Hours
• **INTRODUCTION TO BRIDGES:** Introduction to bridges - definition and basic forms - bridge hydraulic and scour- component of bridge- classification of bridges- introduce the importance of construction methods in design and vice versa- short history of bridge development- site selection and soil exploration for site importance of hydraulic factors in bridge design- general arrangement of drawing computation of discharge- linear waterway- economic span- Introduction to Indian Road Congress (IRC)- load distribution theory- bridge slab- effective width- introduction to methods as per national standard IRC- and international Federal Highway Administration (FHWA) and American Association of State Highway and Transportation Officials (AASHTO)- different types of bridges- impact factor- IRC Loads- wind load- centrifugal forces- economic span length- foundation for bridges- abutments. Introduction to relevant softwares.	**07**
• **DESIGN OF T BEAM AND DECK SLAB OF BRIDGES:** Standard and general features for road bridges (width of carriageway- clearance- load to be considered using IRC dead load- impact load- wind load- longitudinal forces- centrifugal forces- horizontal forces due to water current and Buoyancy effect- earth pressure- design of T beam bridges (up to three girders only) proportioning of components- constructability evaluations- QA/QC- plans- specifications and estimates- analysis of slab using IRC Class AA tracked vehicle- structural design of slab- analysis of cross girder for dead load & IRC Class AA tracked vehicle- structural design of cross girder- analysis of main girder using Courbon's method-calculation of dead load BM and SF- calculation of live load B M & S F using IRC Class AA Tracked vehicle- structural design of main girder- Courbon's Method- Guyon- Massonet Method- Hendry Jaegar Method- Eccentric and Multiple concentric loads.	**09**
• **DESIGN OF T BEAM AND DECK SLAB OF BRIDGES:** Standard and general features for road bridges (width of carriageway- clearance- load to be considered using IRC dead load- impact load- wind load- longitudinal forces- centrifugal forces- horizontal forces due to water current and Buoyancy effect- earth pressure- design	**09**

of T beam bridges (up to three girders only) proportioning of components- constructability evaluations- QA/QC- plans- specifications and estimates- analysis of slab using IRC Class AA tracked vehicle- structural design of slab- analysis of cross girder for dead load & IRC Class AA tracked vehicle- structural design of cross girder- analysis of main girder using Courbon's method-calculation of dead load BM and SF- calculation of live load B M & S F using IRC Class AA Tracked vehicle- structural design of main girder- Courbon's Method- Guyon- Massonet Method- Hendry Jaegar Method- Eccentric and Multiple concentric loads.

- **SUBSTRUCTURES AND SUPERSTRUCTURES:** Design of Piers and abutments- introduction to bridge bearings- hinges and expansion joints. (no design)- methods for bridge superstructure design- methods for bridge substructure design- bridge deck and appurtenant structures; bridge bearings and expansion joints- functions- types and selection of bearings- bearing materials- design of elastomeric bearings for different conditions- expansion joints- types of expansion joints **07**
- **PRESTRESSED CONCRETE BRIDGES:** Introduction to pre-stressed concrete bridges (design concept only)- determination of minimum section modulus- prestressing force and eccentricity (deviation not necessary)- substructures: analysis and design of abetment and pier detailing- drive equilibrium equations in Cartesian and cylindrical polar coordinates. **07**
- **BALANCED CANTILEVER BRIDGES**: Components of balance cantilever bridge. the outer beam, cantilevers and central beam. Suspended beam. Design of prestressed concrete sections – Design of pretension and post tensioned Flexural member statically indeterminate Prestressed Structures **06**
- **CABLE STAYED BRIDGES:** Cable bridge features, Components: Pylon's configurations, Deck girders, Anchorages, Cable stays- design principles- advantages- arrangement of stay cables, Types of towers, Linear analysis of cables and towers **07**

[Total Theory Hours: 45]

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3. **References:**

1. Krishna K. Raju, N. (2017). Design of Bridges. New Delhi: Oxford IBH Publication House.
2. Jagadeesh, T.R., & Jayaram, M.A. (2016). Design of Bridge Structures. New Delhi: PHI Learning Pvt Ltd.
3. Krishna Raju, N. (2006). Prestressed Concrete. New Delhi: Tata McGraw Hill.
4. Dayaratnam, P. (2005). Prestressed Concrete Structures. New Delhi: Oxford & IBH Publication.
5. Ponnuswarmy, S. (2018). Bridge Engineering. New Delhi: Tata McGraw Hill.
6. Raina, V.K. (2018). Concrete Bridge Practice: Analysis, Design and Economics. New Delhi: Tata McGraw-Hill.
7. Subramanian, N. (2008). Design of Steel Structures. New Delhi: Oxford Publications.
8. V. K. Raina- Concrete Bridges Practice – Analysis- Design and Economics- Shroff Publications
9. V. N. Vazirani- M. M. Ratwani- M. G. Aswani- Design of Concrete Bridges- Khanna Publishers
10. IRC: 112- 2011- IRC: 24-2001- IRC: SP: 13-2004- IRC: SF: 54-2000 Code of Practice for Concrete Road Bridges.
11. SAP2000- and CSI Bridge- Computers and Structures

12. R. Barker- J. Puckett- Design of Highway Bridges- Wiley Intercedence
13. AASHTO LRFD- Bridge Design Specifications- AASHTO
14. AASHTO LRFDUS-7 (2014). AASHTO LRFD Bridge Design Specifications – 7 th
15. Edition
16. FHWA NHI-06-088 (2006). Soils and Foundations Reference Manual- Volumes I and II - downloadable free of charge at www.ncsconsultants.com/downloads
17. FHWA-HIF-12-003 (2012). Evaluating Scour at Bridges – 5th Edition- Hydraulic Engineering Circular (HEC) 18. HEC 18
18. FHWA-HIF-12-004 (2012). Stream Stability at Highway Structures – 4th Edition- Hydraulic Engineering Circular (HEC) 20. HEC 20
19. FHW- NHI-09-111 and -112 (2009). Bridge Scour and Stream Instability Countermeasures- Experience- Selection- and Design–Volumes 1 and 2 – 3rd Edition- Hydraulic Engineering Circular (HEC) 23. HEC 23
20. Guidelines for Establishing Scour and Freeboard for Bridges in Pima County- (2012) PCRFCD/PCDOT. Pima County Scour and Freeboard

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4. <u>CO-PO-PSO Mapping:</u>

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	2	3	3	3	3
CO2	2	3	3	3	3	2
CO3	3	3	3	3	3	3
CO4	3	2	3	3	2	3
CO5	3	3	3	3	3	2

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST126: Structural Vibration Control

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Understand different types of structural control methods
CO2	Apply techniques for vibration control to existing structures.
CO3	Understand the testing procedure for isolation system and energy dissipation devices Able to design composite slab deck shear diaphragms, shell roof structure and residential construction.
CO4	Design a vibration control technique for different types of dynamic induced loadings.
CO5	Describe about different types of energy dissipating devices.

2. Syllabus:

Topics	Hours
• **Structural Control**: Historical development of structural control and base isolation, active control, passive control, hybrid control, semi active control; Application to new and existing buildings.	**11**
• **Theory of Vibration Isolation:** Principle of base isolation; Theory of vibration isolation; Components of base isolation; Advantages and limitations; General Design Criteria; Linear and Nonlinear procedures of isolation design; Application of theory to multiple degree of freedom system	**17**
• **Isolation Devices:** Laminated rubber bearing, lead rubber bearing, high damping rubber bearing, PTFE sliding bearing, friction pendulum system and sleeved pile system; Modelling of isolation bearings; Design process for multilayered elastomeric bearings and buckling behaviour of elastomeric bearings; Isolation system testing.	**11**
• **Energy Dissipation Devices:** General requirements; Implementation of energy dissipation devices; Metallic yield dampers, friction dampers, viscoelastic dampers, tuned mass dampers, tuned liquid dampers; Shape memory alloy dampers; Modelling, linear and nonlinear procedures; Detailed system requirements; Application to multistorey buildings; Testing of energy dissipation devices.	**06**

[Total Theory Hours: 45]

3. References:

1. Datta, T. K. (2010). Seismic analysis of structures. John Wiley & Sons.
2. Soong, T. T., & Costantinou, M. C. (Eds.). (2014). Passive and active structural vibration control in civil engineering (Vol. 345). Springer.
3. Mead, D. J. (1999). Passive vibration control. John Wiley & Sons Inc.
4. Dowding, C. H. (1985). Blast vibration monitoring and control (Vol. 297). Englewood Cliffs: Prentice-Hall.
5. Ou, J. (2003). Structural Vibration Control: Active, Semi-active and Intelligent Control.

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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	3
CO2	3	3	3	3	2	3
CO3	3	3	3	3	2	3
CO4	3	3	3	2	2	3
CO5	3	3	3	3	2	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST127: Rehabilitation of Concrete Structures

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Identify the types of distress in structures to illustrate the level of damage- to analyze the course of damage in structures- to identify various repair material- special material.
CO2	Comprehend the mechanisms of damage, remedial measures for structures including building/bridges and relate materials properties.
CO3	Apply suitable techniques for repair and rehabilitation of structures including bridges and buildings- and to choose proper repair materials.
CO4	Conduct the destructive and non-destructive tests and infers its results- to conclude the strength and interpretation of result for applying methods for repairing.
CO5	Evaluate the actual behavior of structures and proper method for retrofitting- and also techno legal aspect of rehabilitation or retrofitting of structures.

2.Syllabus:

Topics	Hours
• **INTRODUCTION:** The repair process- plain concrete: a review: introduction to concrete- materials for making concrete- fresh concrete- structure of concrete- hardened concrete- physical and chemical characteristics of cement composites	**05**
• **MAINTENANCE & REPAIR OF STRUCTURES:** Different Prestressing Need for maintenance and repairs Inspection of Structures for repairs and maintenance methods. for repairs- material and methodology for repairs- Cost of repair & maintenance- Repair to foundation columns- piles- floor- roof and walls	**05**
• **DETERIORATION MECHANISM:** Chemical and physical causes (corrosion)-basic corrosion processes of steel in concert- Corrosion cell- Phases- Pourbaix-Diagram- types of corrosion- factor affecting the rate of corrosion- role of chlorides- corrosion protection techniques a) cathodic protection b) chemical inhibitors- c) re-passivation (patch repairs) d) protection by alkalization f) electrochemical chloride removal; Freeze-thaw durability of concrete- freeze-thaw mechanism- air entrainment- damages due to freeze-thaw- influencing factors- protection methods against freeze-thaw Volume changes- alkali-aggregate reaction in concrete alkali- silica reaction- mechanism- alkali reaction with amorphous silica- alkali reaction with silicates caused by reactions in polyphase siliceous aggregates (shale- granite- sandstone)- alkali carbonate reaction- mechanism of ASR- effects of alkali aggregate reaction-	**07**

typical cracking due to alkali- aggregate reaction- swelling of the concrete due to alkali-aggregate reaction- factors affecting alkali-aggregate reaction

Sulphate attack in concrete sulphate attack of on concrete- sulphate attack mechanism- damages due to sulphate attack- influencing factors- protection methods against sulphate attack

Exposure condition of RC structures- durability- exposure condition- freezing exposure- coastal exposure- acid and thermal exposure- soil exposure

- **INSPECTION AND EVALUATION OF CONCRETE:** Introduction- preliminary consideration- condition survey- in situ compressive strength- locating delamination and cracks- locating embedded steel- monitoring movements and stresses- corrosion evaluation- destructive methods- core-sampling- laboratory tests- load testing **04**

- **DAMAGE EVALUATION – DEFECT AND CRACKING OF CONCRETE:** Philosophy & definition- causes of failure- failure in ancient time & recent times. Deficiency in design drag- material production- construction and use maintenance etc. Failure related problems; Manmade and natural failure or damage. **05**

  Diagnosis of failure; change in appearance on an exposure- chemical deterioration- Mechanical deterioration. Cracking in buildings.

  Failure of flat roofs- balconies- trenches- dams- piles abutments piers- silos- chimney- cooling towers- reinforced cement concrete (RCC) frames- Failure information & Analysis.

- **CONCRETE REPAIR AND REHABILITATION OF DISTRESS STRUCTURES:** Defect in concrete structures- performance requirements- repair process- repair materials- materials selection- repair methods and placement inspection and testing distressed structures- techniques for rehabilitation of concrete structures- retrofitting of structures. **07**

  Format of investigation. shear- torsion compression failure- erection difficulty- failure in tanks silos- space frame- precast assemblies prestressed concrete structure- formwork failure- case studies.

- **INTRODUCTION OF FRP STRENGTHENING CONCRETE STRUCTURES:** Introduction- FRP materials- evaluation of existing structures- flexural strengthening shear strengthening- column strengthening- installation of FRP strengthening systems quality control and quality assurance- additional applications- field applications. **06**

- **STRUCTURE ASSESSMENT & LEGAL ASPECTS:** Art of structure assessment- method of testing- IS code for testing- safety assessment- legal aspects in connection to failure a repair. **03**

- **PREVENTIVE MEASURES FOR DURABILITY OF STRUCTURES:** Proper selection and specification for material- the use of modern techniques for construction- Proper design- better workmanship. **03**

[Total Theory Hours: 45]

3. References:

1. Kay, T. (1992). Assessment and Renovation of Concrete Structures (Ed.). New York: John Wiley & Sons, Inc.
2. Rakshit, K.S. (1994). Construction Maintenance & Repair of Highway Bridges.
3. Champion, S. (1961). Failure & Repair of Concrete Structures. Wiley Publishers.
4. Grass, F.K., Clarke, J.L., & Armer, G.S.T. (1987). Structural Assessment. Butterworth Publisher.
5. Raiker, R.N. (1987). Learning from Failures: Deficiencies in Design, Construction and Service. Structwel Designers & Consultants R&D Centre.

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4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	2	3	3	3	2
CO2	2	2	3	3	3	2
CO3	2	2	3	2	3	3
CO4	3	2	3	3	2	3
CO5	3	3	3	3	3	2

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST128: Fire Resistant Design of Buildings

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describing the importance of fire safety in building
CO2	Designing the structures for fire exposed conditions
CO3	Analysis and design of steel elements exposed to fire
CO4	Design of RCC elements exposed to fire
CO5	Learning provisions of NBC and relevant IS codes of practice

2. Syllabus: **Hours**

Topics	Hours
• **Introduction to Fire Safety in Buildings** a) Objectives of fire safety b) Process of Fire Development c) Concept of fire safety d) Objective of fire resistance e) Controlling Fire spread	**09**
• **Design concept for structures Exposed to Fire** a) Structural Design at Normal Temperature b) Structural Design in fire condition c) Design of Individual Members exposed to fire d) Design of structural assemblies exposed to fire	**11**
• **Steel Structures** a) Fire Resistance ratings b) Steel Temperatures and Protection systems c) Properties of steel at elevated temperature d) Design of individual members exposed to fire	**11**
• **Concrete Structures** a) Behavior of concrete under fire b) Fire Resistance ratings c) Concrete and Reinforcing Steel Temperatures d) Properties of concrete at elevated temperature e) Design of individual members exposed to fire	**08**
• **Provisions of NBC and relevant IS codes of practice**	**06**

[Total Theory Hours: 45]

3. References:

1. Jain, V.K. (2010). Fire Safety in Buildings (2nd ed.). New Delhi: New Age International Publishers.
2. Buchanan, A.H. (2002). Structural Design for Fire Safety. John Wiley & Sons Ltd.
3. Purkiss, J.A. (2007). Fire Safety Engineering Design of Structures. Elsevier.
4. National Institute of Standards and Technology. (2010). Best Practice Guideline for Structural Fire Resistance Design of Concrete and Steel Buildings (NIST Technical Notes 1681).
5. Cement Concrete & Aggregates Australia. (2010). Fire Safety of Concrete Buildings (CCAA T61).
6. Bureau of Indian Standards. National Building Code (Part 4): Fire and Life Safety.
7. National Fire Protection Association. (2009). NFPA 5000: Building Construction and Safety Code.

4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PS03
CO1	03	01	02	03	01	03
CO2	02	01	03	03	02	02
CO3	03	00	03	02	03	03
CO4	03	01	03	03	02	03
CO5	02	00	03	02	02	03

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST129: Design of formwork systems

L	T	P	C
3	-	-	3

1.Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Illustrate the requirement of formwork; classify the formwork systems and their selection; and choose the appropriate material
CO2	Determine the expected loads on formwork systems and calculate the permissible values
CO3	Design of formwork systems for the construction of various structural members.
CO4	Analysis of load distribution on shores and slabs in multi-story building frames.
CO5	Learn the causes of formwork failures and their preventive measures; study the applications of various special formwork.

2. Syllabus:

Topics	Hours
• **Introduction:** Formwork and falsework; Requirement of formwork; Selection of formwork; Classifications of formwork; Materials for formwork	**07**
• **Formwork design concepts:** Loads on formwork systems; Design aspects and assumptions; Permissible stresses and deflections as per IS codes	**04**
• **Formwork for foundations and walls:** Various components of formwork for foundations and walls and their design; Proprietary wall formwork systems	**09**
• **Formwork for columns:** Various components of formwork for columns and their design; Proprietary column formwork systems; Disposable column formwork.	**08**
• **Formwork for beams and slabs:** Various components of formwork for beams and slabs and their design; proprietary beam and slab formwork systems	**05**
• **Formwork in multi-story building construction:** Shoring, reshoring, back shoring and pre-shoring; Striking and cycle time; Simplified analysis and their assumptions and limitations; Load distribution on shores and slabs in multi-story building frames; Calculating the strength of the concrete slab at a given point in time	**06**
• **Formwork failures:** Causes of formwork failures; Deficiencies in designing; Preventive measures; Safety in formwork operations	**02**
• **Special formwork:** Flying formwork: table forms, tunnel formwork, column mounted shoring systems, gang forms; Slip formwork; Formwork for precast concrete; Formwork for bridge structures	**04**

[Total Theory Hours: 45]

3. References:

1. Jha, K.N. (2012). Formwork for Concrete Structures (1st ed.). McGraw Hill.
2. Peurifoy, R.L., & Oberlender, G.D. (2011). Formwork for Concrete Structures. McGraw Hill.
3. Robinson, J.R. (Library Accn No. 29797). Piers, Abutments, and Formwork for Bridges.
4. Austin, C.K. (1960). Formwork to Concrete. London: Cleaver - Hume Press.
5. Moore, C.E. (1977). Concrete Form Construction. Delmar Cengage Learning.
6. IRC 87, Guidelines for the design and erection of falsework for road bridges, The Indian Road Congress, New Delhi, 1984, Reprinted 1996.
7. IS 456, Plain and reinforced concrete - Code of practice, Bureau of Indian Standards, New Delhi, 2000.
8. IS 800, General construction in steel - Code of practice, Bureau of Indian Standards, New Delhi, 2007.
9. IS 875 (Part 1), Code of practice for design loads (other than earthquake) for buildings and structures: Dead loads, Bureau of Indian Standards, New Delhi, 1987, Reaffirmed 2003.
10. IS 875 (Part 2), Code of practice for design loads (other than earthquake) for buildings and structures: Imposed loads, Bureau of Indian Standards, New Delhi, 1987, Reaffirmed 2003.
11. IS 875 (Part 3), Code of practice for design loads (other than earthquake) for buildings and structures: Wind loads, Bureau of Indian Standards, New Delhi, 1987, Reaffirmed 2003.
12. IS 883, (1994), Reaffirmed 2005, Design of Structural Timber in Building- Code of Practice, Bureau of Indian Standards, New Delhi, 1994, Reaffirmed 2005.
13. IS 1161, Steel tubes for structural purposes - Specification, Bureau of Indian Standards, New Delhi, 1998, Reaffirmed 2003.
14. IS 4990, Plywood for concrete shuttering work - Specification, Bureau of Indian Standards, New Delhi, 1993, Reaffirmed 2003.
15. IS 14687, Falsework for concrete structures - Guidelines, Bureau of Indian Standards, New Delhi, 1999, Reaffirmed 2005.

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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	0	2	2	1	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	2
CO4	3	1	3	3	2	2
CO5	1	0	2	2	1	1

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST130: Continuum Mechanics

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Apply principles of elasticity in sufficiently rigorous manner
CO2	Analyze the response of the structure against three-dimensional stress state at a given point
CO3	Formulate the elasticity problems and demonstrate the applications
CO4	Evaluate the solutions of 2D and 3D elementary problems in elasticity
CO5	Implement the concept of plasticity in a plastic analysis

2. Syllabus:

Topics	Hours
• **Basic Concepts and material properties:** Force, Statical and Kinematical indeterminacy deformations, Surfaces forces, Body forces, Uniaxial stress-strain relationship, Macroscopic and microscopic properties of materials, Fatigue, Hysteresis, Elastic, plastic and Viscous models.	**09**
• **Three-dimensional Elasticity:** Stress-tensor, Components of stress tensor, Equations of equilibrium in 2D and 3D Cartesian coordinates, Equilibrium equations in Polar coordinates, Strain-tensor, Components of strain tensor, Saint Venant's Compatibility equations, Plane stress problem, Plane strain problem.	**09**
• **Formulations of problems in elasticity:** Stress-strain relation in 3D field, Generalized Hook's law, Relation between elastic constants, Navier-Lame's equations of equilibrium. Displacement formulation or Navier's equations, Beltrami-Michell compatibility equations.	**09**
• **Application of Theory of Elasticity:** Airy's stress function, Solution of simply supported beams and cantilever beams subjected to different loadings by polynomials. Thick tube subjected to external and internal pressure (Lame's problem), Stress concentration due to a circular hole (Kirsch's problem), Concentrated load acting on the vertex of wedge (Michell's problem), Concentrated load acting on free surface of a plane (Flamant's problem), Bending of prismatic bar, Torsion	**10**
• **Plasticity:** Principal stress state**,** Yield criteria and it's graphical representation, Plastic Stress-strain relations and diagrams, Flow rules, Hardening rule	**08**

[Total Theory Hours: 45]

3. References:

1. Timoshenko, S.P., & Goodier, J.N. (2016). Theory of Elasticity. New York, NY: McGraw Hill Book Co., Inc.

2. Volterra, E., & Gaines, J.H. (2012). Advanced Strength of Materials. New York, NY: Prentice Hall.
3. Venkatraman, B., & Patel, S.A. (2014). Structural Mechanics with Introduction to Elasticity and Plasticity. New York, NY: McGraw Hill.
4. Filonenko, M. (2013). Theory of Elasticity. New York, NY: Dover Publications.
5. Wang, C.T. (2011). Applied Elasticity. New York, NY: McGraw Hill.
6. Chakrabarty, J. (2016). Theory of Plasticity. New York, NY: Elsevier.
7. Budynas, R. (2016). Advanced Strength and Applied Stress Analysis. New York, NY: Prime Publication.
8. Boresi, A.P., & Schmidt, R.J. (2016). Advanced Mechanics of Materials. New York, NY: Wiley.

4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	3
CO2	2	1	3	3	3	2
CO3	3	2	3	2	3	1
CO4	2	1	2	3	3	2
CO5	3	1	2	3	2	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CECSXXX AI/ML BASED APPLICATIONS IN CIVIL ENGINEERING

L	T	P	C
3	-	-	3

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1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Comprehend the basic principles of artificial intelligence (AI) and machine learning (ML) algorithms.
CO2	Understanding Data collection & management tools & techniques for AI/ML application to Civil Engineering.
CO3	Derive the need and benefits of using AI/ML algorithms for developing applications in Civil Engineering using big-data analysis.
CO4	Solve the real-life problems in Civil Engineering using real-time data collection and big-data analysis involving AI/ML tools.
CO5	Evaluate the performance of different AI/ML algorithms towards a given application in civil engineering.

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2. Syllabus:

Topic	Hours
Introduction to Machine Learning: Machine Learning Basics: Data Collection, Data Management, Big data, taxonomy of machine learning algorithms, **Supervised Learning:** Classification – Bayesian Classifier, K-nearest Neighbours, Regression- Linear Regression, Multivariate Regression, Logistic regression. Support Vector Machine (SVM) Algorithm. **Unsupervised Learning:** Clustering- K-means clustering algorithm and Hierarchical clustering algorithm. **Reinforcement Learning:** Q-Learning algorithm.	**08**
Data Collection Apparatuses: Type of data sources, Types of data, Types of sensors, Edge-devices, Introduction to microcontrollers, data communication protocols, Cloud storage and cloud computing, Local server setup, Cloud server setup, Introduction to Python, Introduction to Django server, Database setup.	**08**
Applications in Civil Engineering: Intelligent Transportation systems, smart mobility, shared mobility, Mobility as a Service (MaaS), Real-time data monitoring, Structural health monitoring, Fire resistance evaluation of structures, automation in water resource management, Water quality monitoring, water distribution system monitoring, air and noise pollution monitoring, Rainfall-runoff modelling, Climate change monitoring, Soil liquefaction, Forecasting foundation related parameters, Building occupancy modelling, Building information modelling, Energy demand prediction, Predictive maintenance of equipment, roads and buildings	**15**
APPLICATION PART I: Data Collection and Management: Image processing for real time applications in Civil Engineering**,** Description of available database across specializations**,** Selection of sensors and microcontroller, Integration of sensors with Edge-device, Programming of Edge-devices, Programming of server in Django framework, Collection of sensor data and storing to Database, Cloud computing	**07**

APPLICATION PART II: Big Data Analysis: Selecting the appropriate ML algorithm for analysis, Data Processing, Analyzing the importance of each variable in decision making, and Analysis of processed data. **07**

[Total Theory Hours: 45]

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3. References:

1. Machine Learning using Python, by Manaranjan Pradhan, U Dinesh Kumar, Wiley.
2. A Primer on Machine Learning Applications in Civil Engineering, by Deka P C, Taylor & Francis.
3. Structural Health Monitoring: A Machine Learning Perspective, by Charles R. Farrar, Keith Worden, Wiley.
4. Building Blocks for IoT Analytics, By John Soldatos, Athens Information Technology, Greece, River Publishers.
5. Django - The Easy Way (2nd Edition), By Samuli Natri.
6. Holovaty, A., Kaplan-Moss, J., et al. (2013). The Django Book (Release 2.0).
7. Benjamin, J.R., & Cornell, C.A. (1970). Probability, Statistics and Decision for Civil Engineers. New York, NY: McGraw-Hill.
8. Washington, S.P., Karlaftis, M.G., & Mannering, F.L. (2010). Statistical and Econometric Methods for Transportation Data Analysis (2nd ed.). Boca Raton, FL: CRC Press.
9. Johnson, R.A., & Wichern, D.W. (1992). Applied Multivariate Statistical Analysis. Upper Saddle River, NJ: Prentice Hall.

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4. Other Material:

1. Arduino-ESP32 (Release 2.0.2), Espressif, 2022.

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5. CO-PO-PSO Mapping:

Course Objective	Program Specific Outcome			Program outcomes		
	PSO1	PSO2	PSO3	PO1	PO2	PO3
1	3	3	3	3	3	3
2	3	2	2	3	2	3
3	3	3	3	3	3	3
4	3	2	3	3	3	3
5	3	3	3	3	2	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST107: Computer Modelling, Analysis and Design Lab

L	T	P	C
-	-	4	2

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Comprehend structural modelling techniques using Structural analysis software package
CO2	Perform linear analysis of skeletal structural systems using Integrated Structural analysis and design software
CO3	Develops computer programs for analysis and design of structural elements using C++/MATLAB and Spreadsheet
CO4	Perform linear and non-linear seismic analysis and design of high-rise RC buildings using GUI of Integrated structural analysis and design software
CO5	Comprehend concept of Artificial Neural Network and its application in structural engineering

2. Syllabus:

Topic	Hours
Structural Modelling Techniques- Gravity load generation, Nodal Load, member Load, Area Load/Floor load, defining shear wall etc.	07
Developing structural models using graphical user interphase (GUI) of Integrated structural analysis and design software [ETABS, MidasGen etc.] Understanding preprocessing and post processing phases for solving analysis problem. Integrated analysis and design of RC building frames under gravity and seismic loading	13
Computer Modelling and linear analysis of skeletal structural systems- Plane and space trusses, beams, plane frames and grids	13
Development of spreadsheet tools using Excel/VBA for analysis and design of structural elements	10
Introduction to computer programming in Structural engineering: Development of computer programming for the analysis and design of RC structural elements using C++/MATLAB	08
Introduction to Artificial Neural Network (ANN), Developing ANN model using Multilayer Feed Forward Network for analysis and design of RC structural elements.	08

[Total Practical Hours: 60]

3. References:

1. Balfour, J.A.D. (1992). Computer Analysis of Structural Frameworks (2nd ed.). Oxford, UK: Blackwell Scientific Publications.
2. Kassimali, A. (2021). Matrix Analysis of Structures (3rd ed., SI). CL Engineering.
3. Johnson, D. (2004). Linear Analysis of Skeletal Structures. London, UK: Thomas Telford.

4. Paz, M., & Leigh, W. (2001). Integrated Matrix Analysis of Structures: Theory and Computation. Boston, MA: Kluwer Academic Publishers.
5. Hoit, M. (1995). Computer Assisted Structural Analysis and Modelling. NJ, USA: Prentice Hall.
6. Christy, C.T. (2006). Engineering with Spreadsheets: Structural Engineering Templates Using Excel. ASCE Press.
7. Gilat, A., & Subramaniam, V. (2014). Numerical Methods for Engineers and Scientists: An Introduction with Applications Using MATLAB. Wiley.
8. Sivanandam, S., & Sumathi, S. (July 2017). Introduction to Neural Networks using MATLAB 6. McGraw Hill Education.
9. Arya, C. (May 2022). Design of Structural Elements: Concrete, Steelwork, Masonry and Timber Designs to Eurocodes (4th ed.). CRC Press.

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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	3	3	3	3
CO2	3	2	3	3	2	3
CO3	3	2	3	3	2	2
CO4	3	2	3	3	2	3
CO5	2	1	2	1	2	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST 201: Dissertation Preliminaries

L	T	P	C
-	-	-	14

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Construct a problem statement in advanced structural engineering based on a survey of pertinent literature
CO2	Devise the objective and scope based on research gap identified through critical literature review
CO3	Develop the methodology including tools and techniques to be used in alignment with the scope and objectives
CO4	Execute the theoretical framework of Experimental/Analytical/Numerical investigations
CO5	Prepare the detailed report and presentation to exhibit written and oral communication skills

2. Syllabus:

- The work is assigned to the students immediately after the second semester examination. Thus, the candidate starts working on the given problem during the summer vacation prior to commencement of third semester.
- The preliminary work involved is related to a state-of-art literature review, identification of the area and finalization of the specific problem, with clearly defined title. The presentation of the preliminary-Part 1 is addressed as the 1st stage seminar of the proposed dissertation work. The candidate is expected to present the plan of action and review of the published work related to the area.
- The candidate should submit the report of their 1st Stage and a presentation about the same will be conducted thereafter in front of internal examiners.

[Total Hours: 180]

3. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	2
CO2	3	2	3	3	3	3
CO3	3	2	3	2	3	3
CO4	3	1	3	3	3	3
CO5	0	3	3	0	2	1

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST202: Dissertation

L	T	P	C
-	-	-	20

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Plan the investigations and compile sufficient data to meet the goals
CO2	Analyze the data by employing the appropriate technique(s) to make relevant conclusions
CO3	Develop the analytical /numerical/empirical model using advanced tools and techniques
CO4	Organize the research work in order to prepare the dissertation report according to the specified format
CO5	Defend the project work using a PowerPoint presentation that exhibits the mastery on chosen topic

2. Syllabus:

- After obtaining the approval along with necessary modification from the jury, the candidate proceeds for the second stage of the dissertation work. During this presentation the candidate should submit the report of their project till work. The second stage of dissertation work, which can be termed as the core part can be carried out at any of the advanced institutions, laboratories, centre-of-excellence places, with whom prior permission is obtained through MoU. The MoU can be with the industry, laboratories, and universities, all around the world. A presentation about the same will be conducted thereafter in front of internal examiners.

- Candidates for master's degrees should write and defend a thesis. The candidate should format the thesis as per the guidelines of Institution. The student will open the oral defense with a brief presentation of his or her findings in front of external examiners. After which the members of the thesis committee will question the candidate in an order determined by the advisor. The student should be evaluated upon both:
  1) The overall quality and significance of his or her thesis, and
  2) The oral defense of his or her findings.

[Total Hours: 360]

3. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	2
CO2	3	2	3	3	3	3
CO3	3	2	3	2	3	3
CO4	3	1	3	3	3	3
CO5	0	3	3	0	2	1

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

Teaching and Examination Schemes with Syllabus

of

Master of Technology

in

(Civil) Transportation Engineering and Planning

Department of Civil Engineering

Sardar Vallabhbhai National Institute of Technology, Surat

Vision and Mission of the Institute

Vision

To be one of the leading Technical Institutes disseminating globally acceptable education, effective industrial training and relevant research output

Mission

To be a globally accepted centre of excellence in technical education catalyzing absorption, innovation, diffusion and transfer of high technologies resulting in enhanced quality for all the stake holders

Vision and Mission of the Department

Vision

To be a global centre of excellence for creating competent professionals in Civil Engineering

Mission

• To provide excellent education producing technically competent, globally employable civil engineers who will be leaders in the chosen field

• To undertake research in conventional and advanced technologies fulfilling the needs and challenges of modern society

Foreword

The program was introduced from academic year 2007-2008. The need to introduce the program was realized through planning of large-scale transport infrastructure projects mainly national highways and rural roads. The Vision 2021 for Road Development in India by Government of India highlights the needs for creating sustainable road infrastructure to support and boost the economic growth of the nation. Moreover, the issues related to urban transport systems were also coming to fore which resulted into declaration of Urban Transport Policy, 2007 by the Government of India and subsequent amendment in 2014. Further, the Indian Roads Congress also projected huge requirements of skilled manpower in the highways sector to undertake large scale highway development programs (NHDP,SHDP,PMGSY,GQ-EW Connectivity etc.). Also, the need for efficient operation and management of available transport network has created huge demand for specialized technical manpower in the field of traffic engineering and operation and maintenance management of highways. Further, capacity building was also envisaged for undertaking research as well as teaching in the diverse domains of transportation engineering. Based on this demand assessment, the program in Transportation Engineering & Planning was conceived. The first curriculum was designed through a workshop in March, 2007 in presence of the domain experts from academia (IITs and NITs) research & development organization (CRRI) and field professionals (Roads & Building Department, Government of Gujarat, ILFS). The revision of the curriculum took place again in 2012 through a curriculum revision workshop in presence of experts and alumni also. The second curriculum revision workshop was held in 2017, at which revision of course outcomes, and the mapping of COs with POs was carried out. For preparing draft revision program curriculum document, curriculum of similar programs offered at other NITs (NITW, NITK, NITT and IITs) are referred.

Programme Educational Objectives (PEOs)

The graduates of the M.Tech. Civil (Transportation Engineering and Planning) Programme will:

- Excel in professional career and horn research skills in the field of Transportation Engineering and Planning
- Exhibit professionalism through lifelong learning and able to work in teams for collaborative and various task.
- Graduates will communicate effectively in their team, adapt to emerging trends for sustained growth in independent and reflective learning and exhibit social responsibility and professional ethics.

Programme Outcomes (POs)

The Programme Outcomes of the Master of Technology (Civil) programme in Transportation Engineering and Planning are:

- An ability to independently carry out research /investigation and development work to solve practical problems
- An ability to write and present a substantial technical report/document
- Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

Programme Specific Outcomes (PSOs)

- Acquire thorough knowledge of Transportation Engineering and Planning to analyse the complex problems and evaluate them over a wide range of feasible and economic solutions by applying the advanced tools, techniques and latest softwares in order to meet the needs of the society with due consideration of sustainability and safety.
- Conceptualize and solve complex transportation engineering and planning problems, evaluate wide range of potential solutions and arrive at feasible and optimal solutions to meet the needs of the society with respect to safety, economy, legal and environmental considerations.
- Contribute positively to collaborative – multidisciplinary scientific research demonstrating capacity for self-management and teamwork, decision making based on open-mindedness, objectivity using knowledge of group dynamics to achieve common goals of advancement in learning for self and others.

Teaching Scheme

M.Tech. in Civil Engineering

(with specialisation in Transportation Engineering and Planning)

Sr. No.	Subject	Code	Scheme L-T-P	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
				Th.	T	P		
				Marks	Marks	Marks		
	First Semester							
1	Research Analytical Methods	CETP101	3-0-2	100	-	50	4	100
2	Urban Transport Systems Planning	CETP102	3-1-2	100	25	50	5	100
3	Pavement Analysis and Design	CETP103	3-1-2	100	25	50	5	100
4	Elective -1		3-0-0	100	-	-	3	55
5	Elective - 2		3-0-0	100	-	-	3	55
						Total	**0**	**410**
6	Professional Experience (Optional) (Mandatory for Exit)	CETPP91	0-0-10				5	200 (20 x 10)
	Second Semester							
1	Pavement Construction and Evaluation	CETP104	3-1-2	100	25	50	5	100
2	Traffic Engineering and Management	CETP105	3-0-2	100	-	50	4	100
3	Regional Transport Systems Planning	CETP106	3-0-0	100	-	-	3	55
4	Elective -3		3-0-0	100	-	-	3	55
5	Institute Elective*		3-0-0	100	-	-	3	55
6	Mini Project	CETP106	0-0-4	-	-	100	2	70
						Total	**20**	**375**
7	Professional Experience (Optional) (Mandatory for Exit)	CETPP92	0-0-10				5	200 (20 x 10)

L: Lecture; T: Tutorial; P: Practical; Th: Theory
*to be offered to the PG students of other department and other PG Programs with the department.

Subject Code: Core, Electives, Dissertation Preliminary and Dissertation: **$$##nXX;** Vocational Training: **$$##VXX;** Professional Experience: **$$##PXX;**

$$: Department Name; **##**: M.Tech Course Identity; **n**: Year; **XX**: Core (01 to 10), Elective (11 to 70), Institute Elective (71 to 90), Vocational Training (91 to 92), Vocational Training (93 to 94), Dissertation Preliminary (95), Dissertation (96)
XX last digit odd number (for odd semester); XX last digit even number (for even semester)
Calculation of Notional Hours for the subject containing Theory, Tutorial and Practical
Example: 3-1-2: 3*15+1*15+2*15+10 (Exam)= 100

Elective-I

CETP111 Low Volume Roads
CETP112 Transportation System Analysis
CETP113 Sustainable Transportation
CEGT110 Geosynthetics and Reinforced Soil Structures
CETP114 Highway geometric Design
CETP115 Geospatial Techniques in Transportation Engineering

Elective-II

CETP116 Airport Infrastructure Planning and Design
CETP117 Railways Infrastructure Planning & Design
CETP118 Pavement Materials
CETP119 Waterways Infrastructure Planning & Design
CETP120 Transport Economics
CETP121 Transportation Network Analysis
CETP122 Road Safety and Environment

Elective-III

CETP123 Freight Transportation Planning
CETP124 Public Transport Planning
CETP125 Traffic Flow Theory
CETP126 Operation & Maintenance Management of Pavements
CEGT127 Ground Improvement Techniques
CEGT128 Tunneling and Underground Structures

Institute Elective offered by TEP section:

CECT171 Project Appraisal & Finance
CETP172 Soft Computing Techniques
CETP173 Intelligent Transport System
CETP174 Communication Skills
CECS175 AI/ML Based Applications In Civil Engineering

Sr. No.	Subject	Code	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
			Th.	T	P		
			Marks	Marks	Marks		
	Third Semester						
1	MOOC course – I*	φ	-	-	-	3	70/80
2	MOOC course – II*	φ	-	-	-	3	70/80
3	Dissertation Preliminaries	**CETP295**	-	-	350$	13	520
4	Summer Training		-	-	50	01	40
			Total			**20**	**700-720**
	Fourth Semester						
1	Dissertation	**CETP296**	-	-	600$	**20**	800

$ **Internal**: 40% and **External**: 60%
*Swayam/NPTEL
φ As per 66th IAAC, Dated 20th March, 2024, Resolution No. 66.34 and 61st Senate resolution No. 4, 25th April, 2024

M. TECH. I (TEP) SEMESTER- I **L T P C**

CETP101 RESEARCH ANALYTICAL METHOD **3 0 2 4**

CO1: Perform statistical analysis of the sample data collected using different sampling techniques towards insightful inferences

CO2: Analyse different continuous and discrete probability distributions

CO3: Develop correlations by analysing univariate and multivariate data

CO4: Apply hypothesis testing techniques using different sampling distributions/tests

CO5: Solve the real-world problem with appropriate optimization tool

Course Objective	Program Specific Outcome			Program outcomes		
	PSO1	PSO2	PSO3	PO1	PO2	PO3
1	3	3	3	3	3	3
2	3	2	2	3	2	3
3	3	3	3	3	3	3
4	3	2	3	3	3	3
5	3	3	3	3	2	3

Note: 1: Slightly 2: Moderately 3: Substantially

- **SOCIAL RESEARCH FORMULATION** **(09 Hours)**
  Design of research - Scaling techniques - Sampling design - Design of questionnaire - Data collection and statistical processing, variables, types of variables, scaling of variables, coding of variables in software tools

- **STATISTICS & PROBABILITY CONCEPTS** **(09 Hours)**
  Various probability distributions & their applications - Parameter estimation - Hypothesis testing - Random variables - Method of maximum likelihood - Hypothesis testing to compare multiple population - Statistical quality control

- **HYPOTHESIS TESTING** **(09 Hours)**
  Hypothesis testing, types of error in hypothesis, confidence interval, significance tests for comparing variances and means, tests with small and large samples, two-tail and one-tail student's t-test, analysis of variance (ANOVA), non-parametric tests (Chi-square test and Kolmogorov–Smirnov test), central limit theorem, practice with transportation data.

- **REGRESSION ANALYSIS** **(09 Hours)**
  Simple linear regression, residuals and variances, Assumptions, multiple linear regression, two stage regression, forward, backward and step-wise regression, residual analysis, correlation analysis, type of correlations, coefficient of correlation, Karl-Pearson's coefficient, multivariate data analysis, factor analysis, applications in transportation engineering, goodness-of-fit tests and curve fitting.

- **OPTIMIZATION TECHNIQUES** **(09 Hours)**

Linear programming - Simplex method - Transportation model - Concepts of non– linear programming - Decision theories – Rules - Decision under uncertainty, Applications in Transportation Engineering

(Total contact hours: 45)

TUTORIALS

1. Exercise for measuring central tendency, dispersion and shape of data, graphical representation, plots and pattern, interpretation of results, and histograms using MS office tools and other statistical packages
2. Sampling exercises, data storing, handling, cleaning, and descriptive analysis exercises by using statistical tools.
3. Exercise for fitting probabilistic distributions and hypothesis testing using statistical tools.
4. Exercise for correlation analysis, simple linear and multiple linear regressions, nonlinear regression, using statistical tools.
5. Exercise for parametric and non-parametric tests, test of significance, paired and unpaired sample tests and evaluation, using statistical tools.
6. Exercise for analysis of variance, univariate and multivariate analysis using statistical tools.
7. Exercise for solving optimization problems using solver and using statistical tools.
8. C++ /Java/python/R/MATLAB programming for statistical analysis and probability studies

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REFERENCES:

1. Benjamin J. R., Cornell C. A., *Probability Statistics and Decision for Civil Engineers*, McGraw-Hill, 1970.
2. Kothari, C.R., *Research Methodology: Method and Techniques*, New Age International Publication, 2004.
3. Hines W. W., Montgomery D. C., *Probability and Statistics in Engineering and Management Science*, John Wiley and Sons, New York, 1990.
4. Sharma J.K., *Operation Research: Theory & Applications*, MacMillan India Ltd., 2000.
5. Bhandarkar P.L., Wilkinson T.S., *Methodology & Techniques of Social Research*, Himalaya Publishing House, 1991.
6. Simon P. Washington, Matthew G. Karlaftis, Fred, Mannering L., *Statistical and econometric methods for transportation data analysis*, CRC Press, Second Edition, 2010.
7. Washinton SP, Karlafits MG, Mannering F.L., *Statistical and econometric method for transportation data analysis*, 2nd addition, CRC Press, 2011.
8. Richard A. Johnson, Dean W. Wichern, *Applied Multivariate Statistical Analysis*, Prentice Hall, 1992.
9. Cooley, WW and Lohnes, RR, *Multivariate Data Analysis*, John Wiley, 1971.
10. Joseph F. Hair, Bill Black, Barry Babin, Rolph E. Anderson, Ronald L. Tatham, *Multivariate Data Analysis*, Prentice Hall; 2005.

M. TECH. I (TEP) SEMESTER- I **L T P C**

CETP102 URBAN TRANSPORT SYSTEM PLANNING **3 1 2 5**

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO 1 Prepare a detailed transportation planning process for a city based on problem identification

CO 2 Illustrate various approaches of travel demand using appropriate data

CO 3 Estimate urban travel demand

CO 4 Generate travel and land use patterns between given set of traffic analysis zones and transport network.

CO 5 Design a transit system for an urban route based on estimated demand

Mapping of the Course Outcomes with Program Outcomes:

CO\PSO	PSO1	PSO2	PSO3	PO1	PO2	PO3
CO1	*1*	*2*	*1*	*0*	*1*	*1*
CO2	*1*	*2*	*2*	*1*	*1*	*2*
CO3	*2*	*3*	*2*	*3*	*1*	*2*
CO4	*3*	*2*	*2*	*3*	*2*	*3*
CO5	*2*	*3*	*2*	*2*	*1*	*3*

Note: 0: Not related 1: Slightly 2: Moderately 3: Substantially

URBANISATION & URBAN TRANSPORT PLANNING PROCESS **(06 Hours)**

Urbanisation cycle – Urbanisation & travel demand - NUTP - Urban transportation problems – Sustainable Development Goals & Transport - System's Approach- Conventional and Sustainable Urban Transport Planning process-Study Area Delineation-Comprehensive Mobility Plan

TRAVEL DEMAND APPROACHES **(06 Hours)**

Types of demand models: Aggregate & Disaggregate – Trip based, Tour Based & Activity Based approach- Supply-Demand Relationship - Direct and Cross Elasticities of Demand - Consumer Surplus.

TRIP GENERATION **(04 Hours)**

Productions & Attractions - Influential factors –Trip rate analysis-Category analysis- Simple & Multiple linear regression models

TRIP DISTRIBUTION **(06 Hours)**

Interchange matrix – Growth factor methods – Synthetic methods: Gravity, Opportunity Models, Calibration of Gravity model

MODAL SPLIT **(06 Hours)**

Influential factors – FHWA Procedure – Diversion curves & surfaces-Discrete choice models, Concept, Types, BL, MNL & HL models

TRIP ASSIGNMENT **(06 Hours)**

Trip Assignment procedure – Diversion curves- BPR model - All or Nothing assignment - Multipathassignment-Capacityrestraintassignment–Userequilibriumandsystemequilibriumapproach-Stochasticassignment approach

LANDUSE TRANSPORT INTERACTION **(06Hours)**

Urban system components - Urban spatial structure – Accessibility - Location theory – Land use models -Land use transport models

URBAN PUBLIC TRANSPORTATION **(03 Hours)**

Urban growth and public transport needs – Transit mode classifications -Transit characteristics-Demand estimation- Frequency & Fleet size determination

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(Total contact hours:45)

Tutorials:

Tutorial will cover the following:

1. Study of comprehensive mobility plan of city
2. Aggregate travel demand forecast
3. Use of demand elasticities in demand forecast
4. Use of trip rate, cross classification and regression techniques
5. Application of Furness and Fratar Methods
6. Singly and Doubly Constrained gravity model application
7. Calibration of Gravity Model
8. Application of Intervening and Competing Opportunities model
9. Application of Logit models
10. Application of BPR, A-O-N, Capacity Restraint and Multipath Assignment
11. Use of equilibrium assignment models
12. Land use forecasting, Land Use Transport Interaction Models
13. Transit type, demand, frequency & fleet size

REFERENCES:

1. Bowmen,J. and M.ben Akiva, *Activity based travel Forecasting; in Activity based travel forecasting*. Washington, DC:U.S. DepartmentofTransportation,Report DOT-97-17.
2. ChakrobortyP.,DasN.,*PrinciplesofTransportationEngineering(2nd edition)*,PHI,NewDelhi,2017
3. DickeyJ.W.,*MetropolitanTransportationPlanning*,TataMc-Graw Hill1980
4. KhistyCJ.,LallB.Kent,*TransportationEngineering–AnIntroduction(3rd Edition),Pearson Education*,2017
5. Ortuzar,J.D.,Willumsen,L.G.,*ModelingTransport(4th edition)*,JohnWiley&Sons,2011
6. PapacostasC.S.andPrevedouros,P.D.,*TransportationEngineering&Planning (3rd edition)* ,PHI,NewDelhi,2001
7. P.K. Sarkar, Vinay Maity, G.J.Joshi., Transportation Planning: Principles, Practices and Policies (2nd edition),PHI, New Delhi, 2017

M. TECH. I (TEP) SEMESTER- I **L T P C**

CETP103 PAVEMENT ANALYSIS AND DESIGN **3 1 2 5**

CO1: Comprehend the behaviour of pavement based on material characteristics.

CO2: Analyse the pavement by considering various input parameters appropriately.

CO3: Select the rational method of pavement design.

CO4: Identify the design criteria based on the major failure patterns of pavement.

CO5: Design the pavement with the guidelines given by IRC, AASHTO, and PCA.

Course Objective	Program Specific Outcome			Program outcomes		
	PSO1	PSO2	PSO3	PO1	PO2	PO3
1	2	3	3	3	1	3
2	2	3	1	3	2	3
3	3	3	2	3	2	3
4	3	3	1	1	2	2
5	3	2	1	3	3	3

Note: 1: Slightly 2: Moderately 3: Substantially

- **PAVEMENT TYPES AND MATERIALS** **(03 Hours)**
  Types and component parts of pavements; highway and airport pavements, Basic characteristics of materials used in pavements

- **STRESSES IN FLEXIBLE PAVEMENTS** **(08 Hours)**
  Layered system concepts, Stress solution for one, two- and three-layered systems, Fundamental design concepts, Stress analysis in flexible pavements using KENLAYER; problems

- **STRESSES IN RIGID PAVEMENTS** **(06 Hours)**
  Westergaard’s theory and assumptions, Stresses due to curling, stresses and deflections due to loading, frictional stresses, Stresses in dowel bars and tie bars, Stress analysis in rigid pavements using KENSLABS; problems.

- **FACTORS AFFECTING PAVEMENT DESIGN** **(06 Hours)**
  Variables considered in pavement design, Classification of axle types, standard and legal axle loads, tyre pressure, contact pressure, ESWL, EWLF and EAL concepts, Traffic analysis: ADT, AADT, truck factor, growth factor, lane distribution factor, directional distribution factor and vehicle damage factor

- **DESIGN OF FLEXIBLE PAVEMENT** **(09 Hours)**
  IRC method of flexible pavement design, Asphalt Institute's methods with HMA and other base combinations, MEPDG method of flexible pavement design, Design of flexible pavement shoulders; problems.

- **DESIGN OF RIGID PAVEMENTS** **(09 Hours)**
  IRC method of plain jointed and continuously reinforced rigid pavement design , MEPDG method of rigid pavement design, Design of rigid pavement shoulders. Design of Joints; problems.

- **DESIGN OF PAVEMENT DRAINAGE** **(04 Hours)**
  Detrimental effects of water, methods for controlling water in pavements, Drainage materials: aggregates, geotextiles, pipes, Estimation of inflow, determination of drainage capacity, Drainage design for urban roads and rural roads as per IRC; problems

(Total contact hours: 45)

REFERENCES:

1. **Asphalt Institute.** *Thickness Design – Asphalt Pavements for Highways and Streets Manual Series No. 1 (MS-1)*, Asphalt Institute, Kentucky, USA, 1999.
2. **Das, A.***Analysis of Pavement Structures*, CRC Press, Taylor and Francis Group, Florida, USA, 2015.
3. **Huang, Y.H.** *Pavement Analysis and Design*, Second Edition, Dorling Kindersley (India) Pvt. Ltd., New Delhi, India, 2008.
4. **IRC: 37-2012***Guidelines for the Design of Flexible Pavements*, The Indian Roads Congress, New Delhi, India, 2012.
5. **IRC:58-2015***Guidelines for the Design of Plain Jointed Rigid Pavements for Highways*, The Indian Roads Congress, New Delhi, India, 2015.
6. **Mallick, R.B.** and **T. El-Korchi***Pavement Engineering – Principles and Practice*, CRC Press, Taylor and Francis Group, Florida, USA, 2009.
7. **MEPDG-1.***Mechanistic-Empirical Pavement Design Guide - A Manual of Practice*, Interim Edition, American Association of State Highway and Transportation Officials, Washington, D.C., USA, 2008.
8. **Papagiannakis, A.T.** and **E.A. Masad***Pavement Design and Materials*, John Wiley and Sons, New Jersey, USA, 2008.
9. **Yoder, E.J.** and **M.W. Witczak***Principles of Pavement Design*, Second Edition, John Wiley and Sons, New York, USA, 1975.

M. TECH. I (TEP) SEMESTER- I **L T P C**

CETPP91 PROFESSIONAL EXPERIENCE **0 0 10 5**

CO1 Get acclimatized with the work culture in an industry/research organization towards meeting deadlines and punctuality.

CO2 Apply the knowledge gained from traffic engineering, highway design and construction, and transportation planning to solve real field problems.

CO3 Examine the real field conditions using the relevant concepts studied during the course work.

CO4 Compile the information in connection with the task accomplished during the internship in the form of a report.

Course Objective	**Program Specific Outcome**			**Program outcomes**		
	PSO1	**PSO2**	**PSO3**	**PO1**	**PO2**	**PO3**
1	3	2	1	1	0	1
2	3	3	2	3	1	3
3	3	3	3	3	1	3
4	3	2	2	1	3	1

Note: 1: Slightly 2: Moderately 3: Substantially

Four-week professional experience on major Transportation or Traffic project, is to be carried at National/State/Local Government Project level after the First Semester Examination and prior to opening of Second Semester and the report on the same is to be prepared & submitted duly certified by the Organization.

ELECTIVE-I

M. TECH. I (TEP) SEMESTER- I **L T P C**

CETP111 LOW VOLUME ROADS **3 0 0 3**

CO1: Plan rural road network.

CO2: Select appropriate materials for construction of low volume roads considering cost-effectiveness.

CO3: Design the flexible pavement and rigid pavement for low volume roads.

CO4: Recommend the provision of appropriate road drainage system.

CO5: Select an appropriate construction technique with relevant quality control tests

Course Objective	Program Specific Outcome			Program outcomes		
	PSO1	PSO2	PSO3	PO1	PO2	PO3
1	2	2	2	3	1	3
2	3	3	2	3	1	3
3	3	3	1	3	2	3
4	1	3	1	3	2	3
5	2	1	1	3	2	3

Note: 1: Slightly 2: Moderately 3: Substantially

- **PLANNING OF RURAL ROAD NETWORK** **(09 Hours)**
  Significance of rural road network, Characteristics of low volume roads, Features of PMGSY, MMGSY, Network planning of low volume roads.

- **PAVEMENT MATERIALS FOR LOW VOLUME ROADS** **(09 Hours)**
  Soil Investigations, Properties and Specifications of materials for different layers, utilization of locally available materials in village road projects, marginal materials, non-conventional materials, stabilized roads.

- **DESIGN OF PAVEMENTS FOR LOW VOLUME ROADS** **(12 Hours)**
  Design factors, pavement thickness design as per IRC, design of Semi-rigid pavement, roller compacted cement concrete pavement, specialpavements like inter locking- block paving, design of fly ash embankments.

- **ROAD DRAINAGE** **(06 Hours)**
  Types of drainage, surface and sub-surface drains for low volume roads.

- **CONSTRUCTION PRACTICES FOR LOW VOLUME ROADS** **(09 Hours)**
  Specifications for embankment, subgrade, sub-base, base course and surface course, Construction procedures, Construction equipment, Construction of special pavements for low volume roads.

(Total contact hours: 45)

REFERENCES:

1. IRC, Specifications for Rural Roads, Ministry of Rural Development, Indian Road Congress,New Delhi, 2014, Fifth revision

1. **IRC,** Manual for Rural Roads, Indian Roads Congress
2. Robert A.,Douglas, Low Volume Road Engineering: Design, Construction and Maintenance, , CRC Publishers, 2018, Ninth Edition.
3. IRC, Guidelines for Design and Construction of Cement Concrete Pavements for Low VolumeRoads, IRC:SP62, Indian Road Congress, New Delhi, 2014
4. IRC, Guidelines for the Design of Flexible Pavements for Low Volume Rural Roads, IndianRoads Congress, IRC:SP72, New Delhi, 2015
5. Guidelines for the Design of Stabilized Pavement, IRC:SP89 (P-II), Indian Road Congress, New Delhi, 2018
6. Principles of Pavement Design, Yoder, E.J., and Witczak, M.W., Wiley India Pvt. Ltd., New Delhi, India, 2012, Second Edition

ELECTIVE-I

M. TECH. I (TEP) SEMESTER- I **L T P C**

CETP112 TRANSPORTATION SYSTEM ANALYSIS **3 0 0 3**

CO1:explain role of economic, geographic, political, technological, social and cultural factors in transportation planning

CO2: appraise about the imbalances in transport system in context of the national transport policy

CO3:specify operational and performance characteristics of various transport modes

CO4: analyse level of service of a transport system

CO5: explain various operational controls of different types of transport modes

Course Outcome	Program Specific Outcome			Program outcomes		
	PSO1	PSO2	PSO3	PO1	PO2	PO3
1	2	1	2	1	1	2
2	3	3	3	3	0	2
3	3	3	3	3	1	3
4	3	3	3	3	1	3
5	3	3	3	2	0	3

Note: 0: Not Related 1: Slightly 2: Moderately 3: Substantially

- **TRANSPORTATION AND SOCIETY-FACTORS IN TRANSPORTATION DEVELOPMENT: (10 Hours)**

Functions and Problems in Transportation Planning-Economic, Geographical, Political, Technological, Social and Cultural Factors in Planning of Transportation System. A Brief Historical Development of Transportation Systems in India: Growth of Transport Trends in Traffic - Imbalances in Transport System - New Evidences on Traffic Flow-Optimum Inter Model Mix Study on National Transport Policy. (Students are expected to be introduced to the report on National Transport Policy).

- **TRANSPORT TECHNOLOGY (14 Hours)**

System Classification and their Variation; Study of Conventional Systems of slow & fast modes, Automatic Rapid Transit; Dual Modes, Demand Buses and Variation in other Slow Moving Vehicle Technologies; Unconventional Systems such as Automatic Cabin Systems, PRT Networks etc. Individual Vehicle Motion; Resistance of Air, Water and Ground Modes; Propulsion Forces, Basic Performance Relationships; Acceleration and Velocity Profiles.

- **LEVELS OF SERVICE (14 Hours)**

Factors in Operation-Levels of Service and Performance Criteria - Quality of Service: Capacity and Levels of Service of different Transportation Systems; Safety and Dependability-Flexibility-Speed, Acceleration, Deceleration-Comfort and Environmental Effects of the different Transportation System on the Performance Criteria.

- **OPERATIONAL CONTROLS OF AIR, WATER, RAILWAY AND HIGHWAY TRANSPORTATION SYSTEMS (07 Hours)**
  Functions of Control & Communications-Dispatching Policies - Interval Control - Signals and Traffic Control Devices - Navigational Aids of the different Transportation Systems. Air Traffic Control; Navigational Control. Automatic Signaling Systems of Railway and Highway Movements are proposed to be covered in this.

(Total contact hours:45)

REFERENCES:

Willam, Hay, Introduction to Transportation Engineering, Johnwiley, New York, 1978.
Heggei, I.G., Transportation Engineering Economics, McGraw-Hill Book Company, New York, 1972.
Planning Commision (1980), Report of the National Transport Policy Committee, Govt. of India, 1980.
Edward K. Morlock, Introduction to Transportation Engineering & Planning, International Student Edition, McGraw-Hill Book Company, New York, 1978.
CRRI (1982), Road user Cost Study in India, Final report, Central Road Research Institute, New Delhi.
ITE (1982), Transportation and Traffic Engineering Handbook, Chapters 1,2,3,4,5,6,7 and 14, Prentice Hall, NJ.
Grava S, Urban Transportation Systems, McGraw-Hill, 2002.
Wohl M. and Martin, B V., Traffic System Analysis for Engineers and Planners, McGraw-Hill, New York, 1967.

ELECTIVE-I

M. TECH. I (TEP) SEMESTER- I	**L T P C**
CETP113 SUSTAINABLE TRANSPORTATION	**3 0 0 3**

Students will be able to

CO1: explain effect of transport sector on sustainability

CO2: specify transport planning strategies for sustainable development

CO3:evaluate strategies for development of non-motorised transport

CO4: specify actions for planning for pedestrian and bicyclists facilities

CO5: elaborate on sustainable technologies for mobility management

Course Objective	Program Specific Outcome			Program outcomes		
	PSO1	PSO2	PSO3	PO1	PO2	PO3
1	2	3	3	2	1	3
2	3	3	3	2	1	3
3	3	3	3	3	1	3
4	3	3	3	2	1	2
5	3	3	3	3	3	3

Note: 0: Not related 1: Slightly 2: Moderately 3: Substantially

- **PROBLEM OF SUSTAINABILITY IN TRANSPORT: (03 hours)**

Energy use in transport sector; Transport and climate change; Greenhouse gas emissions, urban air quality, Congestion and sustainability.

- **PLANNING FOR SUSTAINABILITY: (06 hours)**

Urban form, Indicator based planning, landuse transportation integration, Compact City, Public Transit, TOD, NMT, First and Last Mile Connectivity.

- **EVALUATION OF NON-MOTORIZED TRANSPORTATION: (06 hours)**

Surveys, Demand Estimation and Analysis; Crash Data, Barrier Effect; Cycling Condition Evaluation Techniques; Pedestrian Condition Evaluation Techniques; Prioritizing Improvements and Selecting Preferred Options.

- **PLANNING FOR PEDESTRIANS: (06 hours)**

Types of pedestrians and Characteristics; Pedestrian facilities and planning; Pedestrian standards and improvements; Pedestrian facility Design, LOS; Pedestrian safety programs

- **PLANNING FOR BICYCLISTS: (06 hours)**

Types of cyclists and Bikeways; Integrating cycling into roadway planning; Bicycle network planning; Accommodating cyclists on rural roads; Design of Bicycle boulevards/bike paths; Bicycle Parking/storage Facilities; Roadway maintenance for cyclists.

- **SUSTAINABLE POLICIES: (06 hours)**

Continuum of Policies, speed and speed limit policies, national policies, sustainable travel demand management; public awareness; pricing transportation: full cost of transportation, pricing and taxation.

- **SUSTAINABLE TECHNOLOGY: (06 hours)**

Telecommuting, Information and Communication technologies, E-commerce, Alternative Cleaner Fuels, vehicle technologies, fuel cells, Intelligent Transport Systems.

- **NATIONALLY APPROPRIATE MITIGATION ACTIONS: (06 hours)**

Mobility Management policies, Supporting Bicycling, Creating pedestrian friendly facilities, encouraging Public Transportation

(Total Hours: 45)

READING:

1. Black, W. R., Sustainable Transport: Definitions and Responses, In Transportation Research Board, Integrating Sustainability into the Transportation Planning Process, Conference Proceedings 37. Washington, D.C., National Research Council, 2005.
2. Black, W.R., Sustainable transport: Problems and Solutions. Gulford Press, New York, 2010.
3. Cervero, R. Accessible Cities and Regions: A Framework for Sustainable Transport and Urbanism in the 21st Century. Center for Future Urban Transport, Institute of Transportation Studies, University of California, Berkeley, 2005.
4. Mehrdad Ehsani, Fei-Yue Wang and Gary L. Brosch (Eds.) Transportation technologies for sustainability, 2013.
5. Preston L. Schiller, Eric C. Brunn and Jeffrey R. Kenworthy. An Introduction to Sustainable Transportation: Policy, Planning and Implementation, 2010.
6. Rodney Tolley, Editor, Sustainable Transport: Planning for walking and cycling in urban environments; CRC Press, 2003.
7. Tolley, R., Sustainable Transport: Planning for Walking and Cycling in Urban Environments, CRC Press, 2003.

ELECTIVE-I

M.TECH. I (TEP) SEMESTER-I

CEGT110 Geosynthetics and Reinforced Soil Structures	**L**	**T**	**P**	**C**
	3	0	0	3

Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Comprehend the basic principles of reinforced soil for its applications in geotechnical engineering
CO2	Identify the different types of Geosynthetics and its functions
CO3	Evaluate the different engineering properties of Geosyntheticfor its applications in civil engineering
CO4	Appraise different codal provisions for reinforced geotechnical structures
CO5	Design suitable ground improvement and reinforced soil structures using Geosynthetics

CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	1	1	2	2	2
CO2	1	1	1	2	1	2
CO3	2	1	1	2	2	2
CO4	3	3	2	3	3	3
CO5	3	3	3	3	3	3

1-Low 2-Moderate 3-High

Syllabus

- **INTRODUCTION (03 Hours)**

  Historical background of reinforced soil, Principles of reinforced soil through Mohr circle analysis.

- **DIFFERENT TYPES OF GEOSYNTHETICS (04 Hours)**

  Types of geosynthetics like geotextiles, geogrids, geonets, geocells, geo-composites, their manufacturing methods

- **TESTING METHODS FOR GEOSYNTHETICS (05 Hours)**

  Techniques for testing of different index properties, strength properties, Apparent Opening Size, In-plane and cross-plane permeability tests, assessment of construction induced damage and extrapolation of long term strength properties from short term tests.

- **REINFORCED SOIL RETAINING WALLS (11 Hours)**

  Different types of walls like wrap-around walls, full-height panel walls, discrete-facing panel walls, modular block walls. Design methods as per BS-8006 and FHWA methods Construction methods for reinforced soil retaining walls.

- **REINFORCED SOIL SLOPES (07 Hours)**

  Basal reinforcement for construction on soft clay soils, construction of steep slopes with reinforcement layers on comptenet soils, Different slope stability analysis methods like planar wedge method, bi-linear wedge method and circular slip methods. Erosion control on slopes using geosynthetics.

- **APPLICATIONS IN FOUNDATIONS (05 Hours)**

  Binquet and Lee's approach for analysis of foundations with reinforcement layers.

- **DRAINAGE AND FILTRATION APPLICATIONS OF GEOSYNTHETICS (05 Hours)**

  Different filtration requirements, filtration in different types of soils and criteria for selection of geotextiles, estimation of flow of water in retaining walls, pavements, etc. and selection of geosynthetics.

- **PAVEMENT APPLICATION (05 Hours)**

Pavement application: Geosynthetics for separation and reinforcement in flexible pavements, design by Giroud-Noiray approach, reflection cracking and control using geosynthetics. Use of geosynthetics for construction of heavy container yards and raiway lines.

(Total Lecture Hours 45)

References

1. Koerner, R.M. "Designing with Geosynthetics", Prentice Hall, New Jersey, USA, 5th edition, 2005.
2. Jewell, R.A., "Soil Reinforcement with Geotextiles", Special Publication No. 123, CIRIA, Thomas Telford. London, UK, 1996.
3. Geosynthetics - New Horizons, Eds. G.V. Rao, PK Banerjee, J.T. Shahu, G.V. Ramana, Asian Books Private Ltd., New Delhi, 2004.
4. S. K. Shukla. "Geosynthetics and its applications" Thomas Telford, London, 2002.
5. S. K. Shukla. "Fundamentals of Geosynthetic Engineering". CRC Press. 2006.
6. Additional Reading: Design guidelines from IRC, FHWA, BS, IS and other codal organizations.

ELECTIVE-I

M.TECH. I(TEP) SEMESTER-I **L T P C**

CETP114 HIGHWAY GEOMETRIC DESIGN **3 0 0 3**

Pre-Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1: comprehend the basic principles of geometric design in the context of transportation engineering and planning.
CO2: apply design criteria for the geometric design of different roadway elements.
CO3: interpret user perception and its association with geometric design of different roadway elements.
CO4: evaluate the performance of highway alignment by assessing its geometry consistency
CO5: compile the engineering safety measures to improve the reliability in the geometric design.

Mapping of the Course Outcomes with Program Outcomes:

CE693	PSO1	PSO2	PSO3	PO1	PO2	PO3
CO1	3	1	--	2	--	2
CO2	1	3	--	3	2	3
CO3	--	3	3	3	3	3
CO4	2	2	2	2	--	2
CO5	1	3	2	1	2	2

Note: 1: Slightly 2: Moderately 3: Substantially

Introduction: Traffic characteristics, topography and physical features; design controls; speed and safety; space standards for urban; rural and hill roads, access controls, location and spacing of access points (05)

Human and Vehicle Factors: Perceptions and application of human factors in the design and representative vehicle factors used in geometric design, driver expectancy and errors, considerations of high-speed highway facilities(05)

Cross-section Elements: Single lane, two lane, multi-lane highways, expressways and urban roads; street design concepts; bicycle tracks; pedestrian facilities; street furniture; design of speed breaker, road side clear zones (05)

Highway Alignment: Horizontal alignment; curve design; super-elevation design; friction co-efficient;transition curve design; attainment of super-elevation; pavement widening; sight distance on horizontal curves; vertical alignment; gradients; grade compensation; design of vertical curves, 3D alignment and analysis; alignment coordination, vertical clearance for underpass and elevated structures, hill roads considerations, case studies (10)

Intersection and Interchange Design: Design consideration and objectives, visibility requirements, principles of channelization, types of intersections and design,roundabouts, interchange design; on-ramps (flyovers and access-controlled facilities), acceleration and deceleration lanes, two-way turn lanes , case studies (10)

Geometric design consistency: Evaluate inconsistency of geometric design; likelihood of the crashes; reliability-based design; engineering safety measures, traffic calming measures, case studies (05)

Design of Facilities: Design of parking facilities (on-street, off-street, and multi-storeyed); design of bus shelters and bus lay-bye, bus terminal, truck terminals and truck lay-bye, container terminal, toll plaza, foot-over bridge and sky-walk, road side amenities, case studies.(05)

(Total Hours: 45)

REFERENCES:

1. Wright, P.H. &Dixon, K.K., "Highway Engineering," 7^{th} Ed., John Wiley &Sons. (2014)
2. Transportation Research Board (TRB), Highways Capacity Manual, National Research Council, Washington D.C. (2010 edition)
3. Indo-HCM: Indian Highway Capacity Manual (Indo-HCM). CSIR-Central Road Research Institute (CRRI), New Delhi (2017)
4. Khisty, C.J. and Lal, B.K., "Transportation engineering – An Introduction," prentice Hall of India Pvt. Ltd. (2006)
5. Kadiyali, L.R., "Traffic Engineering and Transport Planning," Khanna Publishers. (2008)
6. A policy on geometric design of highways and streets, American Association of State Highway Officials, 2011.
7. Geometric design standards for urban roads in plains (IRC: 86-1983), The Indian Roads Congress, 1983. 3. Geometric design standards for rural (non-urban) highways (IRC: 73-1980), The Indian Roads Congress, 1980.
8. Guidelines for expressways – Part I, Ministry of Road Transport & Highways, 2010.
9. Roadside design guide, American Association of State Highway Officials, 2002.
10. Manual of geometric design standards for Canadian roads, Transportation Associations of Canada, 1986.
11. Pline, J.L., Traffic Engineering Handbook, Institute of Transportation Engineers, 2009.
12. Manual on Uniform Traffic Control Devices, Federal Highway Administration, 2009.
13. S.K. Khanna and C.E.G. Justo, Highway Engineering, Khanna Publishers, Roorkee, 2001

ELECTIVE-I

M. TECH. I (TEP) SEMESTER- I

CETP115 GEOSPATIAL TECHNIQUES IN TRANSPORTATION ENGINEERING

Pre Requisite Courses: Nil

L	T	P	C
3	**0**	**0**	**3**

Course Outcomes: *At the end of the course, students will be able to*

- CO1 Comprehend the basics about the remote sensing, GIS techniques and GPS systems.
- CO2 Conduct remote sensing data acquisition, data processing and their interpretation for practical applications.
- CO3 Analyse and interpret data in GIS environment, development of DTM and able to make network analysis to solve critical transportation problems.
- CO4 Design the experiments using GPS instruments and their practical applications in real world problems.
- CO5 Evaluate the RS, GIS and GPS technological development in the area of Civil Engineering.

Mapping of the Course Outcomes with Program Outcomes:

CE693	PSO1	PSO2	PSO3	PO1	PO2	PO3
CO1	3	1	--	2	--	2
CO2	1	3	--	3	2	3
CO3	--	3	3	3	3	3
CO4	2	2	2	2	--	2
CO5	1	3	2	1	2	2

Note: 1: Slightly 2: Moderately 3: Substantially

- **INTRODUCTION TO GEOINFORMATICS** **(05 Hours)**
  Concepts and fundamentals, energy sources, energy interactions, ideal and real remote sensing systems, fundamentals of aerial photo interpretation, keys, Data acquisition, various remote sensing platforms, Basic concepts of GIS & GPS, Digital image processing.

- **GEOGRAPHICAL INFORMATION SYSTEM** **(08 Hours)**
  Structure of GIS: Cartography, Geographic mapping process, transformations, map projections, Geographic Data Representation, Storage, Quality and Standards, database management systems, Raster data representation, Vector data representation, Assessment of data quality, Managing data errors, Geographic data standards.
- **DATA HANDLING IN GIS** **(08 Hours)**
  GIS Data Processing, Analysis and Modeling: Raster based GIS data processing – Vectorbased GIS data processing – Queries – Spatial analysis – Descriptive statistics – Spatial autocorrelation – Quadrant counts, and nearest neighbour analysis – Network analysis.

- **NETWORK AND DYNAMIC SEGMENTATION** **(08 Hours)**
  Network Applications: Shortest Path Analysis, Closest Facility, Location-Allocations, Urban Transportation Planning model. Dynamic Segmentation: Route creation on new and existing arcs, creation of different types of route with measured polygon shape files. Application of Dynamic Segmentation: Data query with events, Data analysis with routes and events.
- **GLOBAL POSITIONING SYSTEM** **(08 Hours)**
  GPS: Basic concepts, components, factors affecting, GPS setup, accessories, segments- satellites & receivers, Navigation System, GPS Data Collection Methods, Absolute and Differential Positioning, Errors in GPS observations and their correction, Contribution of different errors in GPS observations, GPS applications, Case studies.
- **APPLICATIONS** **(08 Hours)**
  Applications of remote sensing GIS and GPS, Engineering applications, GIS Modeling, Binary Index, Regression and Process Models, Road Accident Modeling, Applications to urban and regional planning, Transportation Engineering, Other Civil Engineering fields.

(Total hours:45)

REFERENCES:

1. Lo, C.P. & Yeung A.K.W., *Concepts and Techniques of Geographic InformationSystems*, Prentice Hall of India, New Delhi, 2002.
2. Kang-tusang Chang, Introduction to Geographic Information Systems, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2002.
3. Anji Reddy, M., *Remote Sensing and Geographical Information Systems,* B.S.Publications, Hyderabad, 2001.
4. Burrough, P.A., *Principles of Geographical Information Systems*, Oxford Publication,1998.
5. Clarke, K., *Getting Started with Geographic Information Systems*, Prentice Hall, NewJersy, 2001.
6. De Mers, M.N., *Fundamentals of Geographic information Systems,* John Wiley & Sons,New York, 2000.
7. Kennedy M., *The Global Positioning System & GIS: An Introduction*, Ann Arbor Press,1996.

ELECTIVE - II

M. TECH. I (TEP) SEMESTER- I **L T P C**

CETP116 AIRPORT INFRASTRUCTURE PLANNING & DESIGN **3 0 0 3**

CO1: To do the planning of orientation of airport elements.

CO2: Analysing the requirement of airport layout with respect to international regulation.

CO3: Design Airport Pavement, Taxiway, and Apron.

CO4: To understand visual aid required for safe landing and takeoff operation from passenger and cargo terminal.

CO5: Summarise the concept of the terminal service facility.

Course Objective	**Program Specific Outcome**			**Program outcomes**		
	PSO1	**PSO2**	**PSO3**	**PO1**	**PO2**	**PO3**
1	2	3	1	3	1	3
2	2	2	2	3	2	2
3	3	3	3	3	2	3
4	1	1	2	2	1	2
5	2	2	2	1	2	2

Note: 1: Slightly 2: Moderately 3: Substantially

- **AIRPORT PLANNING:** **(05 Hours)**
  Airport planning: commercial service aviation, air cargo, and general aviation; civil aviation airports; major acts and policies of the Ministry of Civil Aviation in India

  Aviation organizations and functions: Federal Aviation Administration, International Civil Aviation Organization, Directorate General of Civil Aviation, Airports Authority of India.

  Airport planning studies: airport system plan, airport site selection, airport master plan, airport project plan; continuous planning process.

- **AIRCRAFT CHARACTERISTICS:** **(06 Hours)**
  Landing gear configurations, aircraft weight, and engine types.

  Atmospheric conditions affecting aircraft performance: air pressure, temperature, wind speed, and direction.

  Aircraft performance characteristics: speed, payload, range, runway performance, declared distances, wingtip vortices.

- **AIR TRAFFIC MANAGEMENT:** **(06 Hours)**
  Air traffic separation rules: vertical separation, flight altitudes, longitudinal separation, and lateral separation.

  Navigational aids: ground-based systems, satellite-based systems.

- **GEOMETRIC DESIGN OF THE AIRFIELD: (10 Hours)**

  Airport classification: utility airports, transport airports.

  Runways: runway configurations, runway orientation, the wind rose, estimating runway length, sight distance, and longitudinal profile, transverse gradient, airfield separation requirements, obstacle clearance requirements.

  Taxiways and taxi lanes: widths and slopes, taxiway and taxi lane separation requirements, sight distance and longitudinal profile, exit taxiway geometry, location of exit taxiways, design of taxiway curves and intersections, and end-around taxiways.

- **STRUCTURAL DESIGN OF AIRPORT PAVEMENTS: (06 Hours)**

  Soil investigation and evaluation: CBR, plate bearing test, Young's modulus, the effect of frost on soil strength, subgrade stabilization.

  FAA pavement design methods: equivalent aircraft method, cumulative damage failure method.

  Design of flexible pavements: CBR method, layered elastic design.

  Design of rigid pavements: Westergaard's analysis, finite element theory, joints and joint spacing, continuously reinforced concrete pavements.

- **AIRPORT LIGHTING, MARKING, AND SIGNAGE: (06 Hours)**

  Requirements of visual aids, approach lighting system configurations, visual approach slope aids, threshold lighting.

  Runway lighting, taxiway lighting.

  Runway and taxiway marking, airfield signage.

- **PLANNING AND DESIGN OF THE TERMINAL AREA: (06 Hours)**

  Passenger terminal system and its components.

  Design considerations: terminal demand parameters, facility classification, level of service criteria.

  Terminal planning process: overall space requirements, concept development, horizontal distribution concepts, vertical distribution concepts.

  Apron gate system: number of gates, ramp charts, gate size, aircraft parking type, apron layout, apron circulation, passenger conveyance to aircraft, apron utility requirements.

(Total contact hours: 45)

REFERENCES:

1) Ashford, N. J., Mumayiz, S. A., and Wright, P. H. *Airport Engineering: Planning, Design and Development of 21st Century Airports*, Fourth Edition, John Wiley & Sons, New Jersey, USA, 2011.
2) Horonjeff, R., McKelvey, F. X., Sproule, W. J., and Young, S. B. *Planning and Design of Airports*, Fifth Edition, McGraw-Hill, New York, USA, 2010.
3) Kazda, A., and Caves, R. E. *Airport Design and Operation*, Second Edition, Elsevier, Oxford, U.K., 2007.
4) Khanna, S. K., Arora, M. G., and Jain, S. S. *Airport planning and Design*, Sixth Edition, Nem Chand and Bros, Roorkee, India, 2012.

5) Kumar, V., and Chandra, S. *Air Transportation Planning and Design*, Galgotia Publications Pvt. Ltd., New Delhi, India, 1999.
6) Neufville, R. D., and Odoni, A. *Airport Systems: Planning, Design, and Management*, McGraw-Hill, New York, USA, 2003.
7) Young, S. B., and Wells, A. T. *Airport Planning and Management*, Sixth Edition, McGraw-Hill, New York, USA, 2011.

ELECTIVE - II

M. TECH. I (TEP) SEMESTER- I **L T P C**

CETP117 RAILWAYS INFRASTRUCTURE PLANNING & DESIGN **3 0 0 3**

CO1: Identify the Components of Railway Track, different Railway Gauges

CO2: Design track Gradients as per given requirements and Discuss various Types of Track Turnouts

CO3: Describe purposes and facilities at Railway Stations

CO4: Understanding Interlocking and modern signal system

CO5: Describe Surface Defects on Railway Track and Their Remedial Measures

Course Objective	**Program Specific Outcome**			**Program outcomes**		
	PSO1	**PSO2**	**PSO3**	**PO1**	**PO2**	**PO3**
1	2	1	2	2	1	3
2	3	3	2	3	2	2
3	1	2	3	2	2	3
4	2	2	3	2	3	2
5	3	2	2	3	2	2

Note: 1: Slightly 2: Moderately 3: Substantially

- **PLANNING OF RAILWAY LINES NETWORK** **(05 Hours)**
  Railways operational system, historical background of Indian railways, plans and developments, policy and standards, traffic forecast and surveys, railway alignment, project appraisal, and organization setup.

- **COMPONENT OF RAILWAY TRACK AND ROLLING STOCK:** **(06 Hours)**
  Permanent way, forces acting, rails, the function of rails, rail fixtures and fastenings, sleepers and ballast, rail joints, elements of junctions and layouts, types of traction, locomotives and other rolling stock, brake systems, resistance due to friction, wave action, wind, gradient, curvature, starting, tractive effort of a locomotive, hauling power of a locomotive.

- **GEOMETRIC DESIGN OF RAILWAY TRACK:** **(08 Hours)**
  Right of way and formation, field investigation, geometric design elements, safe speed on curves, speeds computation, string lining of curves, gradients, grade compensation, railway cant and cant deficiency, traction.

- **TRACK CONSTRUCTION** **(06 Hours)**
  Specialconsiderations and construction practices, track laying, Introduction of the maintenance programme, Monsoon, Pre-Monsoon & Post-Monsoon Maintenance, Causes for Maintenance,

Routine Maintenance, Tools for Railway Track Maintenance & Their Functions,Surface Defects and Their Remedial Measures, track drainage, track circuited lengths, track tolerances, mechanized method, off-track tampers, shovel packing, ballast confinement and directed track maintenance, bridge maintenance, renewal, classification of renewal works, through sleeper renewals, mechanized relaying, track renewal trains.

- **SIGNALING AND INTERLOCKING: (04 Hours)**
  Objectives, classification, fixed signals, stop signals, signaling systems, mechanical signaling systems, electrical signaling systems, systems for controlling train movement, interlocking, and modern signaling installations.

- **RAILWAY ACCIDENTS AND SAFETY: (06 Hours)**
  Train accidents, collision and derailments and their causes, restoration of traffic, safety measures, disaster management, classification of level crossings, accidents at level crossings, remedial measures, and maintenance of level crossings.

- **RAILWAY STATION AND YARDS: (06 Hours)**
  Site selection, facilities, classification, platforms, building areas, types of yards, catch sidings, ship sidings, foot over bridges, subways, cranes, weighbridge, loading gauge, end loading ramps, locomotive sheds, ash-pits, water columns, turntable, triangles, traverser, carriage washing platforms, buffer stop, scotch block, derailing switch, sand hump, fouling mark.

- **HIGH-SPEEDED RAILWAYS: (04 Hours)**
  Modernization of railways, the effect of high-speed track, vehicle performance on track, high-speed ground transportation system, ballastless track, track requirement for bullet trains, elevated railways, underground and tube railways.

(Total contact hours: 45)

READING:

1. Satish Chandra and M. Agrawal, *Railway Engineering*, Second Edition, Oxford University Press, 2013.
2. Agarwal, M.M. *Indian Railway Track*, Prabha & Co., New Delhi, India, 1988.
3. Chandra S. and M.M. Agarwal *Railway Engineering*, Oxford University Press, New Delhi, India, 2007.
4. Gupta, B.L. *Text Book of Railway Engineering*, Standard Publishers, New Delhi, India, 1982.
5. Rangwala, S.C. *Principles of Railway Engineering*, Charotar Publishing House, Anand, India, 1988.

S.C. Saxena and S.P. Arora, *A text book of Railway engineering*, DhanpatRai, 2001

ELECTIVE - II

M. TECH. I (TEP) SEMESTER- I **L T P C**

CETP118 PAVEMENT MATERIALS **3 0 0 3**

CO1: Characterise the pavement materials by conducting relevant tests as per procedures mentioned in IRC, IS, ASTM, AASHTO etc.

CO2: Select the appropriate materials for construction based on characteristics of materials, design requirements, cost and availability

CO3: Analyse and interpret the laboratory and field test results to identify the issues related with layer material and recommend the appropriate solution.

CO4: Design the bituminous mixes and cement concrete mixes as per standard practices.

CO5: Develop suitable performance tests and specification for recommending the non-conventional and innovative materials.

Course Objective	**Program Specific Outcome**			**Program outcomes**		
	PSO1	**PSO2**	**PSO3**	**PO1**	**PO2**	**PO3**
1	3	3	1	3	2	3
2	3	1	1	3	2	3
3	3	1	-	3	2	3
4	3	2	-	3	3	3
5	3	2	1	3	3	3

Note: 1: Slightly 2: Moderately 3: Substantially

- **SOIL** **(09 Hours)**
  Role of soil testing in pavement engineering - Subgrade requirements in road constructions, Analysis of soil behavior, Characterisation of soil as subgrade and embankment material, Resilient modulus of soil, Soil stabilization – types, material requirement and design.
- **AGGREGATE** **(06 Hours)**
  Road making aggregates - Mechanical Properties of aggregates and their tests - Design of aggregate gradation
- **BITUMEN** **(09 Hours)**
  Bituminous binders for pavement, Penetration, Viscosity and Performance Grade of bitumen, Emulsion-properties, types, Cut backs, modified binders, Rheology of bitumen and Modified binders, Visco-elastic properties of bituminous binders
- **BITUMINOUS MIX** **(09 Hours)**
  Requirements of a bituminous mix, Design of mix as per MS-2 guidelines, use of filler in mixes, Superpave Mix design method, Performance tests on mixes to evaluate its behavior against cracking, rutting and moisture damage, Characterisation of mix properties used for pavement design
- **CEMENTITIOUS MIXES** **(06 Hours)**
  Types of cementitious mixes, Requirements of cement concrete mixes for pavement, Design of Cement Concrete mix, Design of Dry Lean Concrete, Design of cement treated bases and sub-bases
- **FUTURISTIC PAVEMENT MATERIALS** **(06 Hours)**

Use of innovative materials like Chemical stabilizers, Warm Mix Additives, Geosythtics etc., Use of waste materials for road construction – waste plastics, slag, fly ash, Reclaimed Asphalt Pavement etc.

(Total contact hours: 45)

REFERENCES:

1. Hot Mix Asphalt Materials, Mixture Design and Construction, Brown, E.R., Kandhal, P.S., Roberts, F.L., Kim, R., Lee, D-Y., NAPA Store, 2016, Third Edition.
2. Pavement Design and Materials, Papagiannakis, A.T., Masad, E.A., Wiley, 2008, First Edition.
3. Asphalt Mix Design Methods, MS-2, Asphalt Institute, 2015, Seventh Edition.
4. Bituminous Road Construction in India, Kandhal, P.S., PHI Learning Pvt.Ltd, 2016, First Edition.
5. Specifications for Road and Bridge Works, Ministry of Road Transport and Highways, Indian Roads Congress, New Delhi, India, 2013, Fifth Edition.
6. The Shell Bitumen Handbook, Hunter, R.N., Andy, S., John, R., ICE Publishing, 2015, Sixth Edition.
7. Relevant IS, IRC, ASTM, ASSHTO standards

ELECTIVE - II

M. TECH. I (TEP) SEMESTER- II **L T P C**

CETP119 WATERWAYS INFRASTRUCTURE PLANNING & DESIGN **3 0 0 3**

CO1: To define the importance of Water Transportation and its types

CO2: Identifying the need for Harbour and Port Planning

CO3: Design of Harbour Infrastructure

CO4: Understanding docks and repair facilities

CO5: Evaluate the environmental impact of the Seaport Project and economic evaluation.

Course Objective	**Program Specific Outcome**			**Program outcomes**		
	PSO1	**PSO2**	**PSO3**	**PO1**	**PO2**	**PO3**
1	3	2	3	2	3	3
2	3	2	2	3	2	2
3	3	3	2	3	3	3
4	2	2	2	3	2	3
5	2	3	3	2	2	2

Note: 1: Slightly 2: Moderately 3: Substantially

- **INTRODUCTION TO WATER TRANSPORTATION** **(06 hours)**
  History, Scope, Merits, Developments of Water Transportation in India, Inland waterways, River, Canal, Inland water transportation, Harbor, Port, Dock, Development of Ports & Harbors, classification, Harbor site selection, Harbor dimensioning

- **HARBOUR AND PORT PLANNING:** **(12 hours)**
  selection of site and planning of harbours, location of harbour, traffic estimation, master plan, ship characteristics, harbour design, turning basin, harbour entrances, Site investigations – hydrographic survey, topographic survey, soil investigations, current observations, tidal observations.

  Characteristics of good seaport and principles of seaport planning, size of the seaport, site selection criteria and layout of the seaport, Dry ports, Bulk cargo, Transhipment ports, Port of call, Surveys to be carried out for seaport planning, regional and intercontinental transportation development, forecasting cargo & passenger demand, regional connectivity, cargo handling capacity of the port.

- **HARBOUR INFRASTRUCTURE:** **(09 hours)**
  Ship characteristics, Design of Harbour entrance,Design and construction of breakwaters, berthing structures - jetties, fenders, piers, wharves, dolphins, trestle, moles, navigational aids, requirements of signals, fixed navigation structures, the necessity of navigational aids, lighthouses, beacon lights, floating navigational aids, lightships, buoys, radar.

- **DOCKS AND REPAIR FACILITIES:** **(06 hours)**

Harbor docks, use of wet docks, design of wet docks, repair docks, lift docks, dry docks, keel and bilge blocking, construction of dry docks, gates for dry docks, pumping plant, floating docks, slipways, locks, size of the lock, lock gates, types of gates.

- **DREDGING AND COASTAL PROTECTION: (06 hours)**
  Classification, types of dredgers, choice of dredger, uses of dredged materials, coastal erosion and protection, sea wall, revetment, bulkhead, coastal zone, and beach profile.

- **INLAND NAVIGATION: (03 hours)**
  Inland waterways, Inland water transportation in India, classification of waterways, the economics of inland waterways transportation, and national waterways.

- **IMPACT ANALYSIS: (03 hours)**
  An economic evaluation the of port project, Environmental impacts of port activities.

(Total contact hours: 45)

READING:

1) Ashford, N. J., Mumayiz, S. A., and Wright, P. H. *Airport Engineering: Planning, Design, and Development of 21st Century Airports*, Fourth Edition, John Wiley & Sons, New Jersey, USA, 2011.
2) Horonjeff, R., McKelvey, F. X., Sproule, W. J., and Young, S. B. *Planning and Design of Airports*, Fifth Edition, McGraw-Hill, New York, USA, 2010.
3) Kazda, A., and Caves, R. E. *Airport Design and Operation*, Second Edition, Elsevier, Oxford, U.K., 2007.
4) Khanna, S. K., Arora, M. G., and Jain, S. S. *Airport planning and Design*, Sixth Edition, Nem Chand and Bros, Roorkee, India, 2012.
5) Kumar, V., and Chandra, S. *Air Transportation Planning and Design*, Galgotia Publications Pvt. Ltd., New Delhi, India, 1999.
6) Young, S. B., and Wells, A. T. *Airport Planning and Management*, Sixth Edition, McGraw-Hill, New York, USA, 2011.
7) Bindra, S.P. *A Course in Docks and Harbour Engineering*, Dhanpat Rai and Sons, New Delhi, India, 1992.
8) Seetharaman, S. *Dock and Harbour Engineering*, Umesh Publications, New Delhi, India, 1999.
9) Srinivasan, R. *Harbour, Dock and Tunnel Engineering*, Charotar Publishing House, Anand, India, 1987.

ELECTIVE - II

M.TECH. I (TEP) SEMESTER-I **L T P C**

CETP120 TRANSPORT ECONOMICS **3 0 0 3**

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Comprehend economics principles and estimate road user cost and time value of money.
CO2	Estimate life-cycle cost of transportation projects proposals for different alternatives.
CO3	Evaluate economic feasibility of a transportation project by analysing various alternatives.
CO4	Carry out impact studies on various transport related problems.
CO5	Investigate the economic evaluation methods and their application to transport investments.

Mapping of the Course Outcomes with Program Outcomes:

	PSO1	PSO2	PSO3	PO1	PO2	PO3
CO1	3	2	3	--	--	1
CO2	--	3	1	3	1	3
CO3	1	--	1	2	3	3
CO4	2	2	3	1	2	2
CO5	2	3	--	3	--	3

Note: 1: Slightly 2: Moderately 3: Substantially

PRINCIPLES OF ENGINEERING ECONOMICS **(03 Hours)**

Basic Principles of Economics, Micro and Macro Economics Concept, Transport Economics, Revenue, Profit, Depreciation, Break-even Point, Laws of Return and Congesting Pricing.

TRANSPORTATION DEMAND AND SUPPLY **(10 Hours)**

Demand–Supply Equilibration, Simultaneous Equation Bias in Demand–Supply Equilibration, Dynamics of Transportation Demand and Supply, Concept of Transportation Supply, Elasticities of Travel Demand, Consumer and Social Surplus, Application of the Elasticity Concept: Demand Estimation, Latent Demand, Emerging Issues in Transportation Demand Estimation.

TRANSPORTATION COSTS **(10 Hours)**

Classification of Transportation Costs, Transportation User Costs, Impacts of Demand Elasticity and Induced Demand on User Costs, Cost Estimating Methods, Pavement Cost Analysis, Life Cycle Cost Analysis, Direct and Indirect Benefits, Vehicle Operation Cost (VOC): Components of VOC, Procedure for Assessing VOC, Factors Affecting VOC: Distance and Time Related Congestion Factors, VOC Estimation in Work Zones, VOC Estimation: IRC and AASHTO Practices, HDM-4 Road User Effects. Total Transportation Cost, Value of travel time savings, Value of Increased Comfort and Convenience – Accident Cost, Reduction in Maintenance Cost, Issues in Transportation Cost Estimation

HIGHWAY ECNOMIC EVALUATION **(12 Hours)**

Highway Project Appraisal, Project Alternatives, Scenario Generation, Methods of Economic Analysis, Discounting and Non-Discounting Methods – Net Present Value, Benefit Cost Ratio and Internal Rate of Return, Analysis of Public Projects, Case Studies, Project Feasibility for Highway Sector, Concept and Application of HDM-4.

IMPACT STUDIES **(10 Hours)**

Travel-Time Impacts: Categorization of Travel Time, Procedure for Assessing Travel-Time Impacts, Issues Relating to Travel-Time Value Estimation. Evaluation of Safety Impacts: Procedure for Safety Impact Evaluation, Methods for Estimating Crash Reduction Factors, Elasticity of Crash Frequency, Safety-Related Legislation. Economic Efficiency Impacts: Interest Equations and Equivalencies, Criteria for Economic Efficiency Impact Evaluation. Air Quality Impacts: Air Pollution Sources and Trends, Estimating Pollutant Emissions, Air Pollution from Other Modes, Monetary Costs of Air Pollution.

(Total contact hours: 45)

REFERENCES:

1. Button, K. (1993). *Transport Economics*, 2nd edition, Edward Elgar, Aldershot, UK.
2. Winfrey R. (1969), *Highway Economic Analysis*, International Textbook Company (e-Book).
3. Banerjee A. and D. Mazumdar (1999). *Fundamentals of Economic Principle and Problems.* ABS Publishing House, New Delhi.
4. David H. and Brewer A. (2000). *Transport: An Economics and Management Perspective.* Oxford University Press, UK.
5. Sinha K.C. and Labi S. (2007). *Transportation Decision Making: Principles of Project Evaluation and Programming*. John Wiley & Sons, USA
6. Ian G. Heggie (1972). *Transport Engineering Economics*. McGraw Hill, UK.
7. James L. Riggs, David D. Bedworth and Sabah U. Randhawa (2009). *Engineering Economics,* Tata McGraw Hill, New Delhi.

8. Sarkar P K., and Maitri V. (2010). *Economics in Highway and Transportation Planning,* Standard Publisher, New Delhi, 2010.
9. Indian Roads Congress (IRC) SP: 30 (2019). *Manual on Economic Evaluation of Highway Projects in India*

ELECTIVE-II

M. TECH. I (TEP) SEMESTER- I **L T P C**

CETP121 TRANSPORTATION NETWORK ANALYSIS **3 0 0 3**

CO1: Comprehend, represent and analyse the fundamentals of a given transportation network.

CO2: Relate the impact of junctions on transportation network using objective cost functions.

CO3: Apply the different traffic assignment techniques for monitoring transportation network.

CO4: Create reliability based tools and applications towards enhancing efficacy of the network.

CO5: Formulate network-design based tools and applications towards sustainable development.

Course Objective	Program Specific Outcome			Program outcomes		
	PSO1	PSO2	PSO3	PO1	PO2	PO3
1	3	3	3	3	3	3
2	3	2	2	3	2	3
3	3	3	3	3	3	3
4	3	2	3	3	3	3
5	3	3	3	3	2	3

Note: 1: Slightly 2: Moderately 3: Substantially

- **INTRODUCTION:** **(6 Hours)**
  Networks representation, Network equilibrium, Link and Cost Functions, Incidence matrices, Network capacity, shortest path algorithm.

- **OPTIMALITY AND COST FUNCTIONS:** **(6 Hours)**
  Matrix operations, Objective functions, Traffic representation, Junctions costs, Priority junctions, Signal controlled junctions.

- **ASSIGNMENTS TECHNIQUES:** **(7 Hours)**
  User Equilibrium – Existence and Uniqueness, Deterministic user equilibrium assignment, Most Likely paths, Elastic demand, Time Dependent Networks, stochastic user equilibrium assignment, User Equilibrium with variable demand models, Space-time networks, Case Studies.

- **TRIP TABLE ESTIMATION:** **(8 Hours)**
  Maximum entropy, Generalized least squares, Linear path-flow estimations, Log-linear path-flow estimations, Time-dependent methods, Case Studies.

- **NETWORK RELIABILITY:** **(9 Hours)**
  Connectivity, Structure functions and reliability value, Heuristic methods, Travel time reliability; Considerations of sample size; experiment design for demand forecasting and transportation operations analysis.

- **NETWORK DESIGN:** **(9 Hours)**
  Bi-level programming-Iterative design, Sensitivity based algorithm, Sensitivities of user equilibrium and stochastic user equilibrium methods. Combined trip distribution and assignment, Combined mode choice and assignment, discrete choice models, Application to route choice, Estimating OD matrices, Estimating demand functions, Theory of congestion pricing, Path flows and link flows, Path-based and origin-based methods.

(Total contact hours: 45)

READING:

1. Ahuja R., T. Magnanti, and J. Orlin. Network Flows; Prentice Hall, 1993.
2. Michael Alexander Florian, Michel Gendreau, Patrice Marcotte. Transportation and network analysis: current trends: miscellanea in honor of Michael Florian; Springer Publisher, 2002.
3. Michael G.H. Bell and Yasunori Lida. Transportation Network Analysis, J. Wiley Publishers, 1997.
4. Yosef Sheffi. Urban Transportation Networks: Equilibrium Analysis with Mathematical Programming Methods, Prentice Hall Publishers, 1985.
5. M Patriksson, The Traffic Assignement Problem-Models and Methods, Topics in Transpoirtation, VSP BV, Utrecht, The Netherlands, 1994.
6. Radu Dobrescu, Florin Ionescu,Large Scale Networks: Modeling and Simulation, CRC Press, 2016

ELECTIVE-II

M. TECH. I (TEP) SEMESTER- I **L T P C**

CETP122 ROAD SAFETY & ENVIRONMENT **3 0 0 3**

Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Analyse the present scenario about transport safety and environment with a multidisciplinary approach.
CO2	Examine factors affecting road safety engineering and crash investigation, human factors relating to crashes/accidents, crash/accident.
CO3	Predict hazard identification related to the transport safety and environment and take management measures for improving safety and environment.
CO4	Create awareness about empathetic and improving the present practices related to the Transportation Safety Audit and Environmental Impact Assessment (EIA) for transportation projects.
CO5	Evaluate effectiveness of measures for improving traffic safety and environment.

Mapping of the Course Outcomes with Program Outcomes:

	PSO1	PSO2	PSO3	PO1	PO2	PO3
CO1	2	1	1	2	--	2
CO2	3	1	3	3	2	3
CO3	2	1	3	2	2	3
CO4	1	1	2	1	2	2
CO5	1	2	2	3	--	3

Note: 1: Slightly 2: Moderately 3: Substantially

- **INTRODUCTION** **(06 Hours)**
  Transportation Safety scenario in India and World, Accident Characteristics, Distribution among different modes. Need of Planning for Network, Land Use and Road Environment for Safety, Designing for Safety: Road Link Design, Junctions. Introduction to Road Safety Engineering and Crash Investigation, Human Factors Relating to Crashes/Accidents, Crash/Accident

- **ROAD SAFETY DIAGNOSIS** **(06 Hours)**
  Investigation & Crash Problem Diagnosing, Crash Problems into Solutions & Crash, Investigation Reporting, Crash/Accident, Costing, Economic Appraisal. Safety at Construction Site: Safety provisions for workers at construction site, Construction Zone markings, signs.

- **ROAD SAFETY AUDIT** **(10 Hours)**
  Road Safety Auditing: An Introduction, Concept and need of Road Safety Audit (RSA). Procedures in RSA, design standards, audit tasks, stages of road safety audit, Road Safety Audit Types, key legal aspects, process, audit team and requirements, Checklist, how to use Checklists Road Safety inspection.

- **TRANSPORT AND ENVIRONMENT ISSUES** **(08 Hours)**
  Introduction to transport and the environment: Context, mechanisms and sustainability; Air Pollution: Mechanisms, technology solutions, modelling and social costs; Traffic Noise: Units, sources, and impacts Climate Change: Transport contribution, potential impacts, regulatory framework and policies.

- **MEASUREMENT AND MODELLING** **(08 Hours)**
  Environmental planning and assessment practices, Measurement of environmental impacts of transport: Emissions, air quality and noise, Modelling of environmental impacts of transport: Emissions, air quality and noise, Land use transport relationships.

- **IMPACT ASSESSMENT** **(07 Hours)**
  Environmental Impact Assessment for Transportation Projects: Basic Concepts, Objectives, Transportation Related Environmental Impacts; Vehicular Impacts; Safety & Capacity Impacts; Roadway Impacts, Construction Impacts, Environmental Impact Assessment, Environmental Impact Statement, Environment Audit, Typical case studies.

(Total Lectures: 45hours)

Books Recommended

1. Ezra Hauer, Observational Before-After Studies in Road Safety, Pergamon Press, 1997 (reprinted 2002).
2. Institute of Transportation Engineers (ITE), The Traffic Safety Toolbox: A Primer on Traffic Safety, ITE, 1999.
3. J. Stannard Baker, Traffic Collision Investigation, Northwestern University Center for Public Safety, 2002.
4. Leonard Evans, Traffic Safety, Science Serving Society, 2004.
5. Lynn B. Fricke, Traffic Accident Reconstruction, Northwestern University Center for Public Safety, 1990.
6. Ogden, K.W. Safer Roads: A Guide to Road Safety Engineering. Avebury Technical, 1996.
7. Popkess C.A, Traffic Control and Road Accident Prevention, Chapman and Hall, 1997
8. Rune Elvik and Truls Vaa, The Handbook of Road Safety Measures, Elsevier, 2004.
9. Towards Safe Roads in Developing country, TRL – ODA, 2004.
10. Geetam Tiwari and Dinesh Mohan, Transport Planning and Traffic Safety: Making Cities, Roads, and Vehicles Safer, CRC Press, 2016.
11. IRC SP:88 (2019) Manual on Road Safety Audit
12. Periodic NHAI Circulars.

M. TECH. I (TEP) SEMESTER- II **L T P C**

CETP104 PAVEMENT CONSTRUCTION AND EVALUATION **3 1 2 5**

CO1: Select appropriate earth moving and compaction equipment depending upon the requirement.

CO2: Prepare quality assurance and quality control plans in an attempt to construct better performing pavements.

CO3: Evaluate the pavements based on the functional characteristics.

CO4: Evaluate the pavements based on the structural characteristics.

CO5: Select maintenance technique depending upon the pavement condition.

Course Objective	Program Specific Outcome			Program outcomes		
	PSO1	PSO2	PSO3	PO1	PO2	PO3
1	2	3	2	3	-	3
2	2	3	2	3	1	3
3	3	3	2	3	3	3
4	3	3	2	3	3	3
5	3	3	1	3	3	3

Note: 1: Slightly 2: Moderately 3: Substantially

- **HIGHWAY CONSTRUCTION EQUIPMENT** **(12 Hours)**
  Applications and safety aspects of earth moving equipments, compaction equipments, road making equipments, concreting equipments and paving equipments, Hot mix plants, ready mix plants

- **PAVEMENT CONSTRUCTION** **(09 Hours)**
  Construction and preparation of subgrade, sub-base, base course, construction of bituminous layers, cement concrete surface course as per MoRT&H specifications, Quality control tests during and after construction.
- **FUNCTIONAL EVALUATION OF PAVEMENTS** **(09 Hours)**
  Introduction, factors affecting pavement deterioration, functional condition evaluation techniques, roughness measurements, Identification of uniform sections, serviceability concepts, visual and ride rating techniques.

- **STRUCTURAL EVALUATION OF PAVEMENTS** **(09 Hours)**
  Structural condition evaluation techniques, NDT procedures, rebound deflection, deflection bowl measurement and analysis, IRC overlay design method, structural evaluation using falling weight deflectometer, back calculation of layer moduli, ground penetrating radar for pavement evaluation, evaluation of pavement safety: skid resistance and hydroplaning.

- **PAVEMENT MAINTENANCE** **(06 Hours)**
  Routine maintenance, periodic maintenance, special repairs, responsive maintenance programme, rehabilitation and reconstruction, treatment strategies and selection criteria.

(Total contact hours: 45)

REFERENCES:

1. **Croney, D.** and **P. Croney.** *The design and performance of road pavements*, McGraw-Hill Book Company, London, UK, 1991.
2. **Haas, R., W.R. Hudson** and **J.P. Zaniewski.** *Modern Pavement Management*, Krieger Publishing Company, Malabar, Florida, USA, 1994.
3. **Huang, Y.H.** *Pavement Analysis and Design*, Pearson Prentice Hall, New Jersey, USA, 2004.
4. **Mallick, R.B.** and **T. El-Korchi.** *Pavement Engineering – Principles and Practice*, CRC Press, Taylor and Francis Group, Florida, USA, 2009.
5. **Ministry of Road Transport and Highways.** *Specifications for Road and Bridge Works*, Fifth Edition, Indian Roads Congress, New Delhi, India, 2013.
6. **Papagiannakis, A.T.** and **E.A. Masad.** *Pavement Design and Materials*, John Wiley and Sons, New Jersey, USA, 2008.
7. **Shahin, M.Y.** *Pavement Management for Airports, Roads, and Parking Lots*, Third Edition, Kluwer Academic Publisher, Massachusetts, USA, 2005.
8. **Yoder, E.J.** and **M.W. Witczak.** *Principles of Pavement Design*, Second Edition, John Wiley and Sons, New York, USA, 1975.
9. **Relevant IRC Codes.**

M.TECH. I (TEP) SEMESTER- II **L T P C**

CETP105 TRAFFIC ENGINEERING & MANAGEMENT 3 0 2 4

CO1: Comprehend the basic characteristics of traffic stream at micro and macro level

CO2: Conduct traffic studies and analyse traffic data for practical applications.

CO3: Analyse and interpret data collected through advanced technology for traffic modelling and simulation.

CO4: Design, plan and regulate traffic operation of different roadway facilities and elements.

CO5: Evaluate the causes of road accidents and carry out road safety audits.

Course Objective	Program Specific Outcome			Program outcomes		
	PSO1	PSO2	PSO3	PO1	PO2	PO3
1	3	1		2		2
2	1	3		3	2	3
3	0	3	3	3	3	3
4	2	2	2	2		2
5	1	3	2	1	2	2

Note: 1: Slightly 2: Moderately 3: Substantially

- **TRAFFIC CHARACTERISTICS (07 Hours)**
  Introduction, Human-vehicle-environment system, Characteristics of road users and vehicles, Pedestrian characteristics, vehicular dynamics-force balance equation, Uniform acceleration theory & Non-uniform acceleration theory and its applications.Fundamental traffic flow relationships; Time and space headways, temporal, spatial and flow patterns; Interrupted and un-interrupted traffic; speed characteristics; Vehicular trajectories; Speed characteristics- mathematical distributions; Speed and travel time variations, Computation of AADT, Design Hourly Volume from Short and Long Term Counts to develop adjustment factors, expanding and adjusting traffic counts in urban area and region, case studies and applications.

- **TRAFFIC FLOW MEASUREMENTS (07 Hours)**
  Traffic study components: point, spatial, and network-level measurements, types of data; traffic count studies; Speed and density studies; Travel time and delay studies; Intersection studies, Origin and destination studies, Pedestrian studies; Parking studies, Vehicle detection methods; Advanced methods: GPS, Instrumented/probed Vehicles, Image Processing, Bluetooth/Wi-Fi, Infrared methods, and use of Unmanned Aerial vehicles (UAV). Regional growth factors, Use of statistics in Traffic Engineering.

- **TRAFFIC FLOW ANALYSIS (07 Hours)**
  Differences- heterogeneous and homogeneous traffic flows, Macroscopic, Microscopic & Mesoscopic approach – Types of Flow- Traffic stream characteristics – Space – Time diagram –Fundamental Diagrams using speed-flow-density. Highway capacity and level-of-service analysis at mid-block sections– Introduction to Car-Following Theory and applications under heterogeneous traffic conditions.

- **INTERSECTION TRAFFIC OPERATIONS AND CONTROL (10 Hours)**
  Measurement of traffic flow characteristics at intersections, saturation headway, saturation flow, control delay and operational delay. Traffic signals design - pre-timed fixed control and Automatic traffic control

system(Traffic actuated vs Adaptive traffic control). Design of signal setting - phase diagrams, timing diagram – Signal co-ordination – Area traffic Control System.

- **TRAFFIC OPERATIONS, REGULATIONS AND MANAGEMENT (06 Hours)**
  Traffic Management techniques, one-way, tidal flow, traffic diversion, turning restrictions etc. –TSM planning & Strategies, congestion mitigation strategies in urban areas: congestion index and mapping, corridor-level and area-level traffic management plans, construction work zones, use of Intelligent Transportation system (ITS), Before-after and with-without case studies of successful projects.

- **ROAD SAFETY (08 Hours)**
  Crash studies and analysis, Crash records, Crash data collection and presentation, Crash real-field investigations, Analysis of individual crash. Surrogate safety measures at mid-blocks and intersections. Principles and Practices – Safety along links - Safety at intersections. Road Safety Audit – Countermeasures, evaluation of effectiveness of counter-measures– Road safety programmes.

(Total contact hours:45)

PRACTICALS

1. Traffic Volume Count at Mid-Block Section
2. Turning Movement Count at an Intersection
3. Registration Number Plate Survey
4. Spot Speed Survey
5. Speed and Delay Study by Moving Observer Method
6. Origin and Destination Study- Road Side Questionnaire Survey
7. Parking Inventory & Usage Survey by Patrol
8. Road safety audit: Construction & Operation stage

REFERENCES

1. Drew, D.R., Traffic Flow Theory & Control, McGraw Hill, New York, 1968.
2. Kadiyali, L.R., Traffic Engineering and Transport Planning, Khanna Publishers, New Delhi, 2002.
3. Khisty C J, Lall B. Kent; Transportation Engineering-An Introduction, Prentice-Hall,NJ, 2005
4. May, A.D., Traffic Flow Fundamentals, Prentice – Hall, Inc., New Jersey, 1990.
5. O'Flaherty C A, Highways- Traffic Planning & Engineering, Edward Arnold, UK
6. Pignataro, L.J., Traffic Engineering – Theory & Practice, John Wiley, 1985.
7. Salter, R J., Hounsel, N.D., Highway Traffic Analysis and Design, Macmillan, London, 1996.
8. Relevant IRC codes
9. ITE Hand Book, Highway Engineering Hand Book, Mc Graw - Hill.
10. AASHTO A Policy on Geometric Design of Highway and Streets
11. Gartner N.H, Rathi A.J. and Messer C.J., Traffic Flow Theory – A Revised Monograph, Transportation Research Board, Washington, 1997.
12. McShane W R &Roess R P, Traffic Engineering, Prentice-Hall, NJ, 2010. 8. Mannering, F.L. &Kilareski, W.P., Principles of Highway Engineering and Traffic Analysis, John Wiley & Sons, 2008.

13. Wohl M. and Martin, B V., Traffic System Analysis for Engineers and Planners, McGraw-Hill, New York, 1967.
14. Matson, Smith and Hurd, Traffic Engineering, Mc-Graw Hill Book Co, 1955.
15. A. Veeraragavan, S.K. Khanna and C.E.G. Justo, Highway Engineering, Nem Chand & Brothers, 2014.

M. TECH. I (TEP) SEMESTER- II **L T P C**

CETP121 REGIONAL TRANSPORT SYSTEM PLANNING 3 0 0 3

CO1: Analyse a regional economic and demographic characteristics and forecast for planning horizon

CO2: Forecast multimodal intercity passenger travel demand

CO3: Generate traffic forecast based on historical traffic and economic data

CO4: Assess the road network plan and evaluate economics of a transport facility

CO5: Specify planning and design requirements of freight and passenger transport terminals

Course Objective	Program Specific Outcome			Program outcomes		
	PSO1	PSO2	PSO3	PO1	PO2	PO3
1	1	2	2	1		2
2	2	2	1	3	1	2
3	2	1	1	2	1	3
4	3	3	2	3	2	3
5	2	3	2	1	1	3

Note: 1: Slightly 2: Moderately 3: Substantially

- **REGIONAL PLANNING BASICS (08 Hours)**
  Classification of regions - Transport systems functions - Regional delineation - Regional growth - Concepts of GDP and GNP - Regional economic analysis-factors of production – Employment classification, economic base mechanism, shift and share analysis- input and output analysis, regional income, location quotient, multiplier effects-Population forecast – Linear & Exponential models, Logistic models, Cohort – survival models, Migration

- **DIRECT DEMAND MODELS (06 Hours)**
  Importance & Types- Sketch planning methods – UMOT – SARC model – Mc-Lynn model –Indifference curves - Incremental elasticity models – Pivot point mode choice and destination choice models - Abstract models – Applications for intercity passenger travel demand estimation
- **REGIONAL TRAFFIC FORECASTING (08 Hours)**
  Importance –Traffic growth components & influencing factors – Project Influence Area - Data collection – Growth factor methods – Univariate and Multivariate Time series models-Estimation of cyclic and seasonal components - Diversion analysis–Analysis of level of service for planning horizon
- **HIGHWAY REVENUE & ECONOMIC ANALYSIS (06 Hours)**
  Estimation of toll revenue – Road user benefits – Vehicle operating cost – Road user benefits – Economic evaluation methods – Deterministic approach
- **RURAL ROAD NETWORK PLANNING (06 Hours)**
  Principles – Methodology – Network planning and hierarchy - Network development approach – Saturation method -Multimodal transportation system
- **FRIGHT TRNSPORT & LOGISTICS (05 Hours)**
  Freight demand – Characteristics of Freight Transport – Aggregate and Disaggregate Demand Estimation Models – Equilibrium approach
- **TRANSPORT TERMINAL PLANNING (06 Hours)**

Demand assessment – Location aspects -Passenger terminals, types, facilities, layout - Freight terminals, types, facilities, lay out - Multimodal Freight & Logistics Hubs – Planning and Operational Management – Economics and Cost Analysis.

(Total contact hours:45)

REFERENCES:

1. Chand Mahesh, Puri U.K., *Regional Planning in India*, Allied Publishers, New Delhi,1983.
2. Christopher Blow., Transport Terminals and Modal Interchanges: Planning and Design, Elsevier Pub.,2005
3. Glassion John, *Introduction to Regional Planning*, Hutchinson & MIT press, Cambridge, 1996.
4. IRC: 108-2015., Guidelines for Traffic Forecast on Highways (First Revision), Indian Roads Congress, New Delhi
5. Jason Monios, Rickard Bergqvist.,Intermodal Freight Transport &LogisticsTaylor& Francis Group,,CRC Press,2017
6. Jean-Paul Rodrigue, The Geography of Transport Systems, Routledge Pub., New York 2017. (https://people.hofstra.edu/geotrans/index.html)
7. Kanafani, Adib, K., *Transportation demand Analysis*, Mc Graw Hill, New York,1983.
8. Morlok, K. E., *Introduction to Transportation Engineering*, McGraw-Hill,New York,1978.
9. Oppenheim, N., *Applied Models in Urban and Regional Analysis*, Prentice-Hall, NJ.,1980.
10. Ortuzar, J. D., Willumsen, L.G., *Modeling Transport (4th edition)*, John Wiley & Sons, 2011.
11. Sarkar P., Maitry V., Joshi G.J., Transportation Planning –Principles, Practices & Policies, (2nd edition) PHI,New Delhi 2017.
12. Sarkar P K., MaitriV.,Economics in Highway and Transportation Planning, Standard Publisher, New Delhi, 2010.

M. TECH. I (TEP) SEMESTER- II	**L T P C**
CETP106 MINI PROJECT	**0 0 4 2**

CO 1 Determine a field problem related to transportation engineering / planning and build the need of the study.

CO 2 Decide the objectives and scope of the study based on survey of the literature to derive the solution of the problem

CO 3 Plan and execute the work methodology to handle the project in a group.

CO 4 Compile the collected data to draw valid conclusions and recommending the problem solution.

CO 5 Prepare the project report and present the work to demonstrate written and oral communication skills.

Course Objective	**Program Specific Outcome**			**Program outcomes**		
	PSO1	**PSO2**	**PSO3**	**PO1**	**PO2**	**PO3**
1	1	3	1	3		2
2	2	2	3	3	1	3
3	3	2	2	2	1	3
4	2	3	3	3	3	3
5	1	1	1		3	3

Note: 1: Slightly 2: Moderately 3: Substantially

A mini project on Transportation/Traffic Engineering is to be carried by group of students on the basis of field surveys and observations. The mini project site can be in cities/towns or rural areas.

Final project report is to be submitted & presented for examination after one mini project brief seminar.

M. TECH. I (TEP) SEMESTER- II **L T P C**

CETPP92 PROFESSIONAL EXPERIENCE **0 0 10 5**

CO1 Get acclimatized with the work culture in an industry/research organization towards meeting deadlines and punctuality.

CO2 Apply the knowledge gained from traffic engineering, highway design and construction, and transportation planning to solve real field problems.

CO3 Examine the real field conditions using the relevant concepts studied during the course work.

CO4 Compile the information in connection with the task accomplished during the internship in the form of a report.

Course Objective	Program Specific Outcome			Program outcomes		
	PSO1	**PSO2**	**PSO3**	**PO1**	**PO2**	**PO3**
1	3	2	1	1	0	1
2	3	3	2	3	1	3
3	3	3	3	3	1	3
4	3	2	2	1	3	1

Note: 1: Slightly 2: Moderately 3: Substantially

Six/Eight-week professional experience on major Transportation or Traffic project, is to be carried at National/State/Local Government Project level after the Second Semester Examination and prior to opening of Third Semester and the report on the same is to be prepared & submitted duly certified by the Organization.

ELECTIVE-III

M. TECH. I (TEP) SEMESTER- II **L T P C**

CETP123 FREIGHT TRANSPORTATION PLANNING **3 0 0 3**

Students will be able to

CO1:explain characteristics of freight, freight transport and associated issues

CO2: estimate the freight transport demand

CO3:elaborate various aspects of freight transport planning and operations

CO4: design logistics system for goods and passengers transport

CO5: Identify and explain components of ITS for freight transport

Course Objective	Program Specific Outcome			Program outcomes		
	PSO1	PSO2	PSO3	PO1	PO2	PO3
1	3	3	2	3	1	3
2	2	3	3	3	1	3
3	3	3	3	3	1	3
4	3	3	3	3	2	3
5	2	2	2	2	1	2

Note: 0: Not related 1: Slightly 2: Moderately 3: Substantially

- **INTRODUCTION: (06 Hours)**

Freight Characteristics, Factors influencing Freight Travel, operators, problems in freight transportation, regional vs. urban goods travel, intermodal freight travel issues.

- **FREIGHT DEMAND ESTIMATION: (09 Hours)**

Operations, Planning - purpose, process, Data, Freight Agents, costs, Planning Models and Methods-freight demand estimation and forecasting at regional and urban level, IO model, Freight flow on the network, Performance, Case studies.

- **FREIGHT TRANSPORT PLANNING AND OPERATIONS: (09 Hours)**

Freight supply – capacity issues; freight productivity and performance; freight impacts – safety and environmental issues; route planning and scheduling, collection storage and distribution centres, regulation and enforcement of freight transport.

- **INTERMODAL FREIGHT TRANSPORT: (08 Hours)**

Rail freight operations, Intermodal Networks and Freight Interchanges, Intermodal Road and Rail Vehicles and Maritime Vessels; Air freight; intermodal freight terminals

- **MODELING OF LOGISTICS: (09 Hours)**

Aggregated demand forecast for city logistics; Disaggregated demand forecast for city logistics; Inventory model; Delivery scheduling, Transportation-inventory-production interrelationships, the role of transshipments and terminals in logistic systems for the transportation of goods and passengers.

- **ITS FOR FREIGHT TRANSPORT: (04 Hours)**

Introduction to ITS, Role of ITS, ITS components applicable to Goods travel, case studies.

(Total contact hours:45)

REFERENCES

1. Bramel, J., and Levi, D. S., The Logic of Logistics: Theory, Algorithms, and Application for Logistics Management, Springer-Verlag, New York, USA, 1997.
2. Caplice, Chris, and Yossi Sheffi. *ESD.260J Logistics Systems, Fall 2006*. (MIT OpenCourseWare: Massachusetts Institute of Technology), http://ocw.mit.edu/courses/engineering-systems-division/esd-260j-logistics-systems-fall-2006 (Accessed 7 Jan, 2014). License: Creative Commons BY-NC-SA
3. David Lowe, Intermodal Freight Transport, Elsevier Butterworth-Heinemann Publishers, 2005.
4. Eurodecision, Operational research, Logistics Optimization. http://www.eurodecision.eu/logistics-optimization
5. Konstadinos G. Goulias, Editor, Transportation Systems Planning: Methods and Applications. CRC Press, 2003.
6. Lambert, M. D., Srock, J. R., and Ellram, M. L., Fundamentals of Logistics Management, McGraw Hill International Editions, 1998.
7. Lester A. Hoel, Genevieve Giuliano and Michael D. Meyer, Intermodal Transportation: Moving Freight in a Global Economy, Transportation Research Forum, Eno Transportation Foundation, Washinton DC, 2011
8. Moshe Ben-Akiva, Hilde Meersman and Eddy Van de Voorde, Freight Transport Modelling, Emerald Group Publishing, 2013
9. Myer Kutz, Editor, Handbook of Transportation Engineering, McGraw-Hill Publishers, 2004.
10. NCFRP Report 23, Synthesis of Freight Research in Urban Transportation Planning, TRB, Washington, 2013. http://onlinepubs.trb.org/onlinepubs/ncfrp/ncfrp_rpt_023.pdf
11. Petros A. Ioannou, Intelligent Freight Transportation, CRC Press, 2008
12. Tavasszy and De Jong, Modelling Freight Transport, 1st Edition, Elsevier Publishers, 2013.
13. Taniguchi, E., Thompson, R. G., Yamada, T., and Duin, R. V., City Logistics – Network Modelling and Intelligent Transport Systems, Pergamon, 2001.

ELECTIVE-III

M. TECH. I (TEP) SEMESTER- II	**L T P C**
CETP124 PUBLIC TRANSPORT PLANNING	**3 0 0 3**

CO 1 Elaborate transit system needs for the given urban area

CO 2 Plan the transit route network after determining the transit demand

CO 3 Design the rail and road based urban transit systems

CO 4 Prepare time table, vehicle and crew schedules

CO 5 Carry out performance evaluation of transit operations

Course Objective	Program Specific Outcome			Program outcomes		
	PSO1	**PSO2**	**PSO3**	**PO1**	**PO2**	**PO3**
1	1	1	1	1		2
2	2	3	1	2	1	3
3	3	2	1	1	1	2
4	2	3	2	2	1	3
5	2	2	1	1		2

Note: 1: Slightly 2: Moderately 3: Substantially

- **TRANSIT SYSTEMS: (06 Hours)**

Growth history – Urban growth & transit evolution - Types of Transit Modes - Buses - LRT, RTS - Para Transit - Dial - a- Ride-Taxi- Jitney and Ridesharing – Operational characteristics speed, capacity & payloads – Selection criteria for transit systems.

- **ESTIMATION OF TRANSIT DEMAND: (06 Hours)**

Data requirements & Collection techniques, Conventional Methods - Destination Survey - Transit Stop & Ride Surveys and Analysis - Mode Split Models - Captive and Choice Riders - Attitudes of Travellers - Patronage Determination.

- **TRANSIT DESIGN (08 Hours)**

Frequency & headway determination methods – Rail operation design – Bus operation design – Way capacity & Station capacity –Transit level of service

TRANSIT ROUTE NETWORK PLANNING: (07Hours)

Route Systems - Route Location, Route Structure, Route Coding Techniques, Route Capacity - Planning of Transit Network - Different Types - Service Area Coverage - Evaluation - Selection of Optimal Network - Path Building Criteria - Integration with UTPS.

SCHEDULING: (08 Hours)

Patterns of transit Services - Frequency of Services - Special Services - Single Route Bus Scheduling - Fleet Requirement, Marginal Ridership Concept - Use of Optimisation Technique - Load Factor - Depot Location - Spacing of Bus Stops

MASS TRANSIT CORRIDOR IDENTIFICATION & PLANNING: (04 Hours)

Corridor identification - Network Compression Method - Planning of Rapid Transit System - System Selection - Aesthetics and Noise Consideration - Cost of Construction - Station Arrangements - Platform Capacity - Fare Structure, Transit Marketing.

TRANSIT TERMINALS AND PERFORMANCE EVALUATION: (06 Hours)

Performance Evaluation – Efficiency, Capacity, Productivity and Utilisation – Performance Evaluation Techniques and Application – System Network Performance – Transit Terminal Planning and Design.

(Total contact hours: 45)

REFERENCES

1. Black, Alan, *Urban Mass Transportation Planning*, McGraw- Hill,Inc., New York,1995.
2. Ceder, A.,*Public Transit Planning and Operation: Theory, Modeling and Practice*, B-H Elsevier Ltd., MA, 2007.
3. David A. Hensher, Bus Transport: Economics, Policy and Planning. Research in Transportation Economics Volume 18. Elsevier Publications, 2007.
4. G.E. Gray and CA Hoel: Public Transport Planning Operation and Management, Prentice Hall; 2nd Edition, 1992
5. Khisty C J., LallB.Kent, *Transportation Engineering – An Introduction*, Prentice-Hall, NJ, 2005
6. Papacostas C.S. and Prevedouros, P.D., *Transportation Engineering & Planning*, PHI, New Delhi,2002
7. Vukan, R. Vuchic, *Urban Public Transportation: Systems & Technology*, John –Wiley & Sons, New Jersey, 2007.
8. Vukan, R. Vuchic, *Urban Transit: Operations, Planning and Economics*, John –Wiley & Sons, New Jersey, 2005.
9. Vukan,R.Vuchic et. al, *Timed Transfer System Planning, Design and Operation: Final Report*, The Program,1983.
10. Sarkar P., Maitry V., Joshi G.J., Transportation Planning –Principles, Practices &Policies,PHI,New Delhi (2014)
11. Simpson, Barry J., Urban Public Transport Today. Taylor & Francis Routledge Publisher, 2003
12. Tiwari G., Urban Transport for Growing Cities – High Capacity Bus System, MacMillan India Ltd., 2002
13. Tyler N., Accessibility and the Bus System – Concepts and Practice, Thomas Telford, 2002.

14. Transit Capacity and Quality of Service Manual, Third Edition, Transit Cooperative Research Program (TCRP) Report 165: Transport Research Board, 2013.

ELECTIVE-III

M. TECH. I (TEP) SEMESTER- II **L T P C**

CETP125 TRAFFIC FLOW THEORY **3 0 0 3**

CO1: Comprehend, represent and analyze the variation of traffic flow characteristics at microscopic and macroscopic levels using trajectory data

CO2: Recognize various car-following theories for identifying key factors affecting driving behavior and traffic performance

CO3: Evaluate traffic stability and efficiency for varying roadway and traffic conditions by means of design and control parameters

CO4: Solve real world transportation problems using queuing theory

CO5: Apply programming and simulation skillset to interpret and analyze data pertaining to traffic and transportation engineering problems

Course Objective	**Program Specific Outcome**			**Program outcomes**		
	PSO1	**PSO2**	**PSO3**	**PO1**	**PO2**	**PO3**
1	3	3	3	3	3	3
2	3	2	2	3	2	3
3	3	3	3	3	3	3
4	3	2	3	3	3	3
5	3	3	3	3	2	3

Note: 1: Slightly 2: Moderately 3: Substantially

- **TRAFFIC STREAM CHARACTERISTICS** **(10 Hours)**

Measurement of microscopic and macroscopic traffic flow characteristics using loop detectors; Time-space plots; density measurement techniques, gap acceptance behavior. Use of counting, interval and translated distributions for describing Vehicle Arrivals, Headways,driver reaction times, Speeds, Gaps and Lags under varying roadway and traffic conditions. Vehicle-following, lane-changing, lateral and longitudinal vehicular movements under homogeneous and heterogeneous traffic conditions, identifying vehicle-following pairs using vehicular trajectory data numerical simulation of car-following behaviour.

- **TRAFFIC STREAM MODELS** **(12 Hours)**

Fundamental Equation of Traffic Flow, continuity equation and its assumptions, Speed-Flow-Concentration Relationships(Fundamental and Macroscopic Fundamental Diagrams), Pedestrian stream models, Normalized Relationship, Fluid Flow Analogy Approach, Gas-kinematic models, Shock-Wave Theory, Car-Following Theory, Advanced Car-Following Models, Psycho-physical models, Traffic Flow Stability, Social-force models, Hysteresis based behavioral studies, two-fluid model, driver behaviour modelling under heterogeneous traffic conditions, Introduction to two-dimensional modelling approach.

- **SHOCKWAVE ANALYSIS:** **(06 Hours)**

Shock wave equations; Types of shockwaves and propagation; Shock waves at toll gates, Signalized intersections, Shockwaves due to incidents; Shockwaves due to bottlenecks, Shockwave analysis on flow-density diagram and using simulation.

- **QUEUING ANALYSIS** **(07 Hours)**

Fundamentals of Queuing Theory, Demand Service Characteristics, Deterministic Queuing Models, Stochastic Queuing Models, Multiple Service Channels, Models of Delay at Intersections and Pedestrian Crossings, Queuing examples and numerical analysis; Determination of number of servers, Average time and vehicles in Queuing system.

- **TRAFFIC SIMULATION:** **(10 Hours)**

Monte Carlo method; Generation of Pseudorandom Numbers; Discrete Random deviates; Simulation methods; Fundamentals of simulation, Introduction to factorial experimental designs, Fractional factorial design, Components of traffic simulations models, vehicle arrival and movement models, mixed traffic flow simulation, Simulation model development strategies; Study of large scale simulation models; Scanning Technique; Time based and Even-based methods; Examples of Macroscopic, Mesoscopic, and Microscopic based simulation models, Calibration and Validation of Simulation Models; methodology for calibrating and validating a microscopic traffic simulation model; Case studies of application of simulation for various transportation engineering problems.

(Total contact hours: 45)

REFERNCES

1. Boris S. Kerner, Introduction to Modern Traffic Flow Theory and Control, Springer; 1st Edition. Edition, 2009
2. Drew, DR., Traffic flow theory and control McGraw Hill Book Company, 1976.
3. Fred L. Mannering, Scott S. Washburn, Kilareski Walter P., Principles of Highway Engineering and Traffic Analysis, Wiley India Pvt Ltd., 4th edition, 2011.
4. Gerlough DL and Huber MJ. Traffic Flow Theorya Monograph: TRB special report 165, 1992.
5. Highway Capacity Manual, Transportation Research Board, Washington, D.C., 2010.
6. May, A.D. Traffic Flow Fundamentals, Prentice Hall, 1st Edition, 1990.
7. Mc Shane WR and RP Roess: Traffic Engineering Prentice Hall, 1998.
8. Roger P. Roess, E. S. Prassas and W. R. McShane, Traffic Engineering, Prentice Hall, 4th edition, 2010.
9. Barceló, J. "Models, Traffic Models, Simulation, and Traffic Simulation". Barceló, J. ed. Fundamentals of traffic simulation. New York: Springer, 2010.
10. Banks, J; Carson, JS; Nelson, B.L. Discrete-event system simulation. 5th ed. Upper Saddle River, NJ: Prentice-Hall, 2010.
11. Clifford S., E. S. Park, Laurence R. R., Transportation Statistics and Microsimulation, CRC Press, Taylor and Francis group, 2011.
12. Neylor, T.H. et al., Computer Simulation Techniques, John Wiley, 1966
13. Winnie Daamen, Christine Buisson, Serge P. Hoogendoorn,Traffic Simulation and Data: Validation Methods and Applications, CRC Press, 2014

    Edward Chung, Andre-Gilles Dumont,Transport Simulation: Beyond Traditional Approaches, CRC Press, 2009.

ELECTIVE-III

M. TECH. I (TEP) SEMESTER- II **L T P C**

CETP126 OPERATION & MAINTENANCE MANAGEMENT OF PAVEMENT 3 0 0 3

CO1: Comprehend the maintenance management program of pavement by prioritizing the need for maintenance

CO2: Evaluate the functional and structural condition of existing pavement

CO3: Identify appropriate tools for pavement evaluation

CO4: Examine the need for rehabilitation of pavement

CO5: Design the overlays for the existing pavement using various approaches using BBD and FWD

Course Objective	Program Specific Outcome			Program outcomes		
	PSO1	PSO2	PSO3	PO1	PO2	PO3
1	3	3	1	2	1	2
2	3	2	1	3	1	2
3	3	1	2	3	1	1
4	3	2	1	3	1	1
5	3	3	1	3	3	3

Note: 1: Slightly 2: Moderately 3: Substantially

- **INTRODUCTION** **(09 Hours)**

Operation and maintenance (O&M) of the Project Highway - Model Concession Agreement (MCA) for various types of PPP projects -Management and Organization - Project Cycle -Levels of Management - Administration and Logistics - Site Management - Road Maintenance – Approach – Organization - Management Activities

- **OPERATIONAL MANAGEMENT ACTIVITIES** **(09 Hours)**

Road Inventory - Assessment of Maintenance Requirements – Drainage - Running Surface – Structures - Setting Priorities - Planning Maintenance Works - Implementation - Work Activities and Task Rates - Tools for Maintenance Works - Reporting and Monitoring

- **DISTRESS MEASURING EQUIPMENT** **(09 Hours)**

Functional and structural evaluation - Functions parameters such as roughness - Distress, rutting - Skid resistance,etc. testing using conventional and NSV techniques, structural parameters such as structural capacity - Benkelman beam - bump integrator - demonstration of equipment for dynamic testing of pavements (LWD) - pavement skid resistance measuring equipment - fatigue testing equipment

- **DESIGN OF OVERLAYS** **(09 Hours)**

Types of Overlays - Design Methodologies - Flexible overlays - Rigid overlays - design of overlay by Benkelman beam and falling weight Deflectometer - Asphalt Institute Method - Portland Cement Association Method, -AASHTO Method, Use of Geosynthetics in Pavement Overlays.

- **PAVEMENT MANAGEMENT SYSTEM** **(09 Hours)**

Development of Pavement Management System: Concepts of pavement management systems, pavement performance prediction – concepts, modeling techniques, structural conditional deterioration models, mechanistic & empirical models, functional condition deterioration models, unevenness deterioration models and other models, ranking and optimization methodologies

(Total contact hours: 45)

REFERENCES:

1. Hass, R., Hudson, W.R. and Zaniewski, J., Modern Pavement Management, Krieger,1994

2. Hass, R. and Hudson, W.R., Pavement Management System, McGraw Hill Company, Inc,1978

3. Yang H. Huang, Design of functional pavements, Pearson Prentice Hall, 2004

4. Yoder, E.J. and Witczak, M.W., Principles of Pavement Design, John Wiley and sons, 1975

5. Khanna S.K., Justo C.E.G., Highway Engineering, Nem Chand & Bros., Roorkee

6. Kadiyali L.R., Principles & Practice of Highway Engineering, Khanna Publishers, 2003

7. Relevant IRC code & Infrastructure development form Planning commission of India Publication, MORTHs Publications

ELECTIVE-III

CEGT127 Ground Improvement Techniques

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Identify the mineral composition responsible for the weak soil deposits and problems associated with it.
CO2	Understand general construction procedures and inspection items for ground improvement techniques.
CO3	Analyse various index/strength properties of soil and suggest suitable ground improvement method.
CO4	Ability to design the ground improvement methods as per site requirements using various national/international codal guidelines.
CO5	Ability to prepare numerical modelling for various ground improvement techniques.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	1	1	1	1	1
CO2	1	1	1	1	1	1
CO3	2	2	2	3	3	2
CO4	2	2	2	2	2	2
CO5	2	2	3	3	3	2

1-Low 2-Moderate 3-High

Syllabus

- **INTRODUCTION** **(06 Hours)**
  Ground Improvement: Definition, Objectives of soil improvement, Classification of ground improvement techniques, Factors to be considered in the selection of the best soil improvement technique. Weak Deposits – Identification – Problems associated with weak deposits – Mitchel chart of applicability of treatment methods – Principles – Suitable methods . Mechanical Modification, Principle of modification for various types of soils

- **DEEP GROUND IMPROVEMENT** **(10 Hours)**
  Insitu compaction of cohesion less soil – Dynamic compaction & blasting - Vibroflotation – stone column – Encased stone column, stone column design as per codal provisions – strengthening of sub soil by stone column installation. Lime piles.

- **HYDRAULIC MODIFICATION** **(06 Hours)**
  Definition, aim, principle, techniques. gravity drain, lowering of water table, multistage well point, vacuum dewatering. Discharge equations. Design of dewatering system including pipe line effects of dewatering, Preloading, vertical drains, sand drains. Assessment of ground condition for preloading, Electro kinetic dewatering.

- **GEOSYNTHETICS AND REINFORCED SOIL** **(06 Hours)**
  Types of geosynthetics like geotextiles, geogrids, geonets, geocells, geo-composites, their functions, applications and manufacturing methods. Index properties and Strength properties of Geosynthetics. Historical background of reinforced soil, Principles of reinforced soil. Concept of MSE wall and Reinforced Soil slopes.

- **GROUTING** **(06 Hours)**

Types of Grouts, Desirable characteristics of Grout, Grouting methods- Permeation grouting, displacement-compaction grouting, displacement-soil fracture grouting, Jet or Replacment-displacement grouting. Grouting pressure, Grouting technology

- **SOIL STABILIZATION** **(06 Hours)**
  Soil stabilization with admixtures like lime, flyash, cement etc, Properties of chemical components, reactions and effects. Bitumen, tar or asphalt in stabilization

- **MISCELLANEOUS METHODS** **(05 Hours)**
  Micro piles, Soil nailing, Ground Anchors, ground freezing and heating methods.

(Total Lecture Hours 45)

Books Recommended

1. Hausmann M.R. “Engineering Principles of Ground Modification” McGraw Hill Publishing Company, New York, 2013
2. Koerner, R.M. "Designing with Geosynthetics", Prentice Hall, New Jersey, USA, 6th edition, 2012.
3. Jie Han, " Principles and Practice of Ground Improvement, Wiley India, 2018
4. Patra N. H., “Ground Improvement Techniques”, Vikas publishing house Pvt. Ltd., 2013.
5. Chu, Jian; Indraratna, B; Rujikiatkamjorn, C, " Ground improvement case histories: compaction, grouting, and geosynthetics", Butterworth Heinemann - Elsevier, 2015
6. Design guidelines from IS code, FHWA, BS and other codal organizations

CEGT128 Tunneling and Underground Structures

L	T	P	C
3	0	0	3

Course Outcomes (COs)

At the end of the course the students will be able to:

- CO1 Comprehend the design aspects of various underground structures in soil and rockmass
- CO2 Identify the excavation methods for construction of underground structures in different ground conditions
- CO3 Analyze the underground structures in rock and soil using elastic and elastoplastic solutions
- CO4 Appraise the underground structure using empirical, observational, analytical and numerical approaches
- CO5 Design the support and safety system for underground structures

CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	2	2	2	1	2
CO2	2	2	3	2	2	3
CO3	2	3	3	2	3	3
CO4	3	3	3	2	3	3
CO5	3	3	3	3	3	3

1-Low 2-Moderate 3-High

Syllabus

- **INTRODUCTION** **(6 Hours)**
  Introduction to underground space and tunnelling, History, Tunnelling challenges, Types and classification of underground opening, Factors affecting design, Design methodology, Functional aspects, Size and shapes, Support systems, Codal provisions

- **EXCAVATION METHOD AND MACHINERY** **(10 Hours)**
  Drilling and Blasting for Underground and Open Excavations, blast operation planning, Explosive products, Blast Design, controlled Blasting techniques, Blasting damage and control, safe practices with explosives and shots. Tunnel driving techniques, TBM techniques, Bottom up and bottom down method, Tunnelling in difficult ground condition, Underground supports, theory of arching, rock loads and loads on tunnel linings, Safety aspects, Case histories.

- **ANALYSIS AND DESIGN OF UNDERGROUND OPENINGS** **(12 Hours)**
  Analysis of Underground openings, stresses around different shapes, initial state of stresses, Closed form solutions, BEM, FEM, Design based on analytical methods, Empirical methods based on RSR, RMR, Q systems, Observational method- NATM, Convergence-confinement method, Design based on Wedge failure and key block analysis, Design of Shafts and hydraulic tunnels.

- **DESIGN OF SUPPORT SYSTEM** **(8 Hours)**
  Tunnel support systems, Different type of supports, Standup time, Ground Reaction Curve, Stability of excavation face and Tunnel portals, Surface settlement due to underground works, Ground subsidence study, Use of appropriate software packages, Shotcreting including some case histories, Underground instrumentation and monitoring

- **TUNNEL HEALTH AND SAFETY ISSUES** **(6 Hours)**

Construction methods, Ventilation, De-watering, Control and monitoring system: services, operations and maintenance, Lighting: specifications, maintenance, emergency lighting, Power supply and distribution, Water supply and distribution, Safety provisions, Localized hazards, Fire hazards in highway tunnels, Rapid transit tunnels. Surveillance and control system for highway tunnels. Tunnel finish, Rehabilitation: Inspection methods, Repairs, Tunnel construction contracting.

(Total Lecture Hours 42)

Books Recommended

1. Ramamurthy T., "Engineering in Rocks for Slopes, Foundation and tunnels", Prentice Hall of India Pvt Ltd, New Delhi, 2010.
2. Kolymbas, D., "Tunneling and tunnel mechanics: A rational approach to tunnelling", Springer Publications. 2008.
3. Goodman, R. E., "Introduction to Rock Mechanics", John Wiley & Sons, 1989.
4. Hoek, E. and Brown, E. T., "Underground excavations in rock", The Institute of mining and metallurgy. 2005.
5. Brady, B. H. G. and Brown, E. T., "Rock mechanics for underground mining", Springer Publication, 2006.
6. Obert, L. and Duvall, W.I., "Rock mechanics and the design of structures in rock", John Wiley and Sons, 1967.
7. Chapman D, Metje, N and Stark A, "Introduction to tunnel construction", Spon Press, Taylor and Francis, 2010.

INSTITUTE ELECTIVE

M. TECH. I (TEP) SEMESTER- II **L T P C**

CECT171 PROJECT APPRAISAL & FINANCE MANAGEMENT **3 0 0 3**

Course Outcomes: *At the end of the course, students will be able to-*

CO1 To learn the fundamentals of project formulation and appraisal.
CO2 To monitor and control project.
CO3 To implement concepts of finance management in practice.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*3*	*3*	*3*	*1*	*1*	*2*	*3*	*1*	*2*	*1*	*1*
CO2	*3*	*2*	*3*	*1*	*1*	*2*	*3*	*1*	*2*	*2*	*2*
CO3	*3*	*3*	*3*	*1*	*1*	*2*	*3*	*1*	*1*	*1*	*2*

Note: 1: Slightly 2: Moderately 3: Substantially

1. **Project Formulation**
Generation and screening of project ideas, project identification, preliminary analysis, market, technical, financial, economic and ecological-pre-feasibility report and its clearance, project estimates and techno-economic feasibility report, detailed project report, different project clearances required

2. **Project Appraisal**
NPV, BCR, IRR, ARR, urgency-payback period, assessment of various methods, Indian practice of investment appraisal, international practice of appraisal, analysis of risk, different methods for selection of a project and risk analysis in practice, ownership structures; BOT, BOLT, BOOT models.

3. **Project Accounting**
Profit and loss, balance sheet, income statement, ratio analysis, depreciation and amortization, preparation of financial statements, inflation accounting and corporate practices in India

4. **Working Capital Management**
Policy for working capital, estimating working capital need, inventory management, account receivable, credit and cash management, managing payments to supplies and outstanding, capital investment decisions, techniques of capital budgeting, cost of capital. Cash flow analysis

5. **Long term financing and Budgeting**
Working of financial institutes in India and abroad, self financing, stock exchanges, types of securities, borrowings, debentures, types of budgeting, procedure for master budget, key factor, budget manual, and new approach to budgeting, cash flow forecast.

REFERENCES:

1. Prasanna Chandra (1995) Projects Preparation, Appraisals, Budgeting and Implementation, 3rd Edition, Tata Mc Graw Hill Publishing Co. Ltd.
2. Van Horne, J C (1990). Fundamentals of Financial Management, Printice-Hall of India Ltd.
3. Taylor, G A (1968) Managerial and Engineering Economy. East-West Edition.
4. Thuesen, H G (1959) Engineering Economy, Prentice-Hall, Inc.
5. Brigham, E F (1978) Fundamentals of Financial Management, the Dryden Press, Hinsdale, Illinios.
6. Kolb, R W and Rodriguez, R J (1992) Financial Management D C Heath & Co.
7. Walker, E W (1974) Essentials of Financial Management, Prentice Hall of India Private Limited, New Delhi.
8. Collier, C A and Ledbetter, W B (1982) Engineering Cost Analysis, Harper & Row Publishers.
9. Maheshwari, S N (2002) Cost and Management Accounting, Sultan Chand & Sons.
10. Lifson, N W and Shaifer, E F (1982) Decision and Risk Analysis for Construction Management, John Wliey & Sons.
11. Degoff, R A and Friedman, H A (1985) Construction Management, John Wliey & Sons.
12. McCarthy, J F (2010) Construction project management - A managerial approach, Pareto publishers.

INSTITUTE ELECTIVE

M. TECH. I (TEP) SEMESTER- II **L T P C**

CETP172 SOFT COMPUTING TECHNIQUES **3 0 0 3**

Students will be able to

CO 1 Appraise characteristics of real-world problem and select appropriate soft computing technique

CO 2 To solve the optimization problems using the genetic algorithm.

CO 3 Identify vagueness in data and formulate appropriate fuzzy model

CO 4 Calibrate ANN model by adopting appropriate activation function, learning rule and training algorithm

CO 5 Formulate FL - ANN hybrid model for the given real-world problem

Mapping of the Course Outcomes with Program Specific Outcomes (TEP) and Program Outcomes:

CO\PO	PSO1	PSO2	PSO3	PO1	PO2	PO3
CO1	1	2	2	1	0	3
CO2	2	2	2	3	1	3
CO3	3	2	2	2	0	3
CO4	1	3	2	3	0	3
CO5	3	3	1	2	0	3

Note: 0: Not related1: Slightly2: Moderately 3: Substantially

Mapping of the Course Outcomes with Program Specific Outcomes (UP) and Program Outcomes:

CO\PO	PSO1	PSO2	PSO3	PO1	PO2	PO3
CO1	3	3	2	1	0	3
CO2	3	2	2	3	1	3
CO3	2	1	1	2	0	3
CO4	3	1	1	3	0	3
CO5	2	2	3	2	0	3

- **GENETIC ALGORITHMS** **(12 Hours)**
  Goals of optimization - Comparison with traditional methods - Schemata – Terminology in GA – Strings, Structure, Parameter string - Data Structures – Operators - Coding fitness function – Algorithm - Applications.

- **FUZZY LOGIC** **(12 Hours)**
  Concepts of uncertainty and imprecision – Sets - Concepts, properties and operations on Classical sets & Fuzzy Sets - Classical & Fuzzy Relations - Membership Functions - Fuzzy Logic – Fuzzification - Fuzzy Rule based Systems – Fuzzy propositions - Applications.

- **ARTIFICIAL NEURAL NETWORKS** **(12 Hours)**

Basics of ANN; Models of a Neuron – Topology: Multi Layer Feed Forward Network (MLFFN), Radial Basis Function Network (RBFN), Recurring Neural Network (RNN) – Learning Processes: Supervised and unsupervised learning. Error-correction learning, Hebbian learning; Single layer perceptrons - Multilayer perceptrons - Least mean square algorithm, Back propagation algorithm Applications.

- **HYBRID SYSTEMS** **(09 Hours)**
  Fuzzy neural systems – Genetic Fuzzy Systems – Genetic Neural Systems.

(Total contact hours: 45)

REFERENCES:

1. Timothy J.Ross, Fuzzy Logic with Engineering Applicatios, McGraw-Hill
2. Simon Haykin, Neural Netwroks, PrenticeHall
3. J.M. Zurada, .Introduction to artificial neural systems., Jaico Publishers
4. H.J. Zimmermann, Fuzzy set theory and its applications., III Edition, Kluwer Academic Publishers, London.
5. Suran Goonatilake, Sukhdev Khebbal (Eds), .Intelligent hybrid systems., John Wiley & Sons, New York, 1995.

INSTITUTE ELECTIVE

M. TECH. I (TEP) SEMESTER- I **L T P C**

CETP173 INTELLIGENT TRANSPORT SYSTEM **3 0 0 3**

CO1: Identify various components of Intelligent transportation systems (ITS) and supporting technologies

CO2: Comprehend the role of ITS and its applications for improving the performance of the transportation system

CO3: Analyse automated traffic data collected using sensors for varying roadway and traffic conditions

CO4: Apply ITS related strategies for varying roadway and traffic conditions using design and control parameters

CO5: Evaluate ITS related strategies for improving the sustainability, efficiency and safety of transportation system considering different case studies

Course Objective	Program Specific Outcome			Program outcomes		
	PSO1	PSO2	PSO3	PO1	PO2	PO3
1	3	3	3	3	2	3
2	3	2	2	3	2	3
3	3	3	3	3	3	3
4	3	2	3	3	3	3
5	3	3	3	3	3	3

Note: 1: Slightly 2: Moderately 3: Substantially

- **INTRODUCTION TO ITS** **(05 Hours)**

Definition Objectives, Historical Background, Benefits of ITS – Introduction to Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), Geographic Information Systems (GIS), Traffic control and monitoring aspects, components of ITS.

- **ADVANCED TRAVELER INFORMATION SYSTEMS (ATIS)** **(04 Hours)**

Trip Planner and its impact, Traffic density measurement, Variable message signs, Parking guidance, Weather information and variable speed limits, Impacts of ATIS.

- **ADVANCE VEHICLE MONITORING SYSTEMS** **(04 Hours)**

Security CCTV systems, Wireless Sensor Network and RFID, Blue-tooth and Wi-Fi sensors, inductive loop detectors and image processing techniques, Impacts of AVMS

COMMERCIAL VEHICLE OPERATIONS (CVO) (04 Hours)

Emergency vehicle notification systems, Automatic road enforcement, Variable speed limits, Collision avoidance systems, Dynamic Traffic Light Sequence, Cooperative systems on the road, Automatic number plate recognition by Image processing, Impacts of CVO.

ITS APPLICATIONS (05 Hours)

Advanced Traffic Management Systems (ATMS) Advanced Vehicle Control Systems (AVCS), Advanced Public Transportation Systems (APTS), Advanced Rural Transportation Systems (ARTS), Automated Highway Systems, and Framework for evaluating ITS related strategies.

ITS PROGRAMS IN THE WORLD (05 Hours)

Overview of ITS implementations in developed countries, ITS in developing countries, Potential applications of offline and online real time measurement of traffic flow characteristics.

INTELLIGENT SUPPORTING TECHNOLOGIES (18 Hours)

Wireless communications, Standards and Cellular Technology, ITS Data acquisition and processing, Hardware and Software--Micro-Controllers, PLC, Embedded systems, Ubiquitous Computing, Sensing Technologies, Detectors/Detection Techniques— Triangulation Technique, Inductive loop detection, Video vehicle detection, Microwave detection, etc. Global Positioning System (GPS).

(Total contact hours:45)

REFERENCES:

1. AUSTROADS, The Implication of Intelligent Transport Systems for Road Safety, Austroads Incorporated, 1999.
2. Bob Williams, Intelligent Transport Systems Standards, Artech House Publishers, 2008.
3. Sumit Ghosh and Tony Lee, Intelligent Transportation Systems, CRC Press, ISBN: 0849300673.
4. Chris Drane and C. R. Drane, Positioning Systems in Intelligent Transportation Systems, Artech House Publishers, ISBN: 0890065365.
5. Judy Mc Queen and Bob Mc Queen, Intelligent Transportation System and Architecture, Artech House Publishers, ISBN: 089006525X
6. Asad J. Khattak , Intelligent Transportation Systems: Planning, Operations, and Evaluation, CRC Press
7. Chowdhary M A and A Sadek. Fundamentals of Intelligent Transportation systems planning. Artech House Inc., US, 2003.
8. M.A. Chowdhury and A. Sadek, Fundamentals of Intelligent Transportation Systems Planning, Artech House, 2010.
9. R P Roess, S E Prassas, and W R McShane. Traffic Engineering. Pearson Education International, 2005.
10. Yokota Toshiyuki and Weiland Richard. Its standards for developing countries. (3), 2004.
11. Stough, R. Intelligent Transport Systems: Cases and Policies, Edward Elgar, 2001, Artificial Intelligence and Intelligent Transportation Systems, National Academy Press, 2010.
12. ITS Hand Book 2000: Recommendations for World Road Association (PIARC) by Kan Paul Chen, John Miles.

13. Sussman, J. M., Perspective on ITS, Artech House Publishers, 2005.
National ITS Architecture Documentation, US Department of Transportation, 2007 (CDROM).

INSTITUTE ELECTIVE

M. TECH. I (TEP) SEMESTER- II **L T P C**

CETP174 COMMUNICATION SKILLS **3 0 0 3**

CO1: Select the appropriate element of grammar during the written and oral communication.

CO2: Select the active voice or passive voice of the sentence based on the type of the content.

CO3: Write the technical report with by incorporating required components.

CO4: Comprehend the importance of personal factors during oral communication

CO5: present the content verbally in individual as well as group presentations and discussions.

Course Outcomes	Program Specific Outcome			Program outcomes		
	PSO1	PSO2	PSO3	PO1	PO2	PO3
1	-	-	2	-	3	2
2	-	-	2	-	3	2
3	-	-	2	-	3	2
4	-	-	2	-	3	2
5	-	-	2	-	3	2

Note: 1: Slightly 2: Moderately 3: Substantially

- **ENRICHING LANGUAGE SKILLS** **(12 Hours)**
  Functional English Grammar – Parts of Speech - Uses of Articles – Prepositions – Tenses - Active and Passive Voice - Conditional Sentences - Punctuation - Common Errors and Vocabulary

- **WRITTEN COMMUNICATION** **(15 Hours)**
  Paragraphs - Kinds and Construction – Letters - Seven C's of Letter Writing and Structure - Reports- Kinds and Structure - Research Paper - Characteristics and Components - E-mail etiquette

- **ORAL COMMUNICATION** **(18 Hours)**
  Non-Verbal Communication- Body Language, Space and Personal Appearance; Job Interviews- Objectives and Preparation - Group Discussion- Speaking in a GD - Presentation – Planning - Structuring and Nuances of Delivery

(Total Contact Hour: 45)

REFERENCES:

1. Bovee, Courtland L.; Thill, John V.& Chaturvedi, Mukesh. *Business Communication Today*. 9th Edition. New Delhi: Dorling Kindersley (India) Pvt. Ltd. Pearson. 2011.
2. Raymond V. Lesikar and Marie E. Flatley. *Basic Business Communication: Skills for Empowering the Internet Generation*. New Delhi: Tata McGraw Hill, 2008.

3. Farahthullah, T.M. *Communication Skills for Technical Students*. 5th Edition, Kolkatta: Orient Blackswan, 2009.
4. Quirk, Randolph & Greenbaum, Sidney. *A University Grammar of English***.** 5th Edition, New Delhi: Pearson, 2009.
5. Raman, Meenakshi & Sharma Sangeeta**.** *Technical Communication Principles and Practice***.** 2nd Edition, New Delhi: Oxford University Press, 2011.
6. Rizvi, M. Ashrif**.** *Effective Technical Communication*. New Delhi: Tata McGraw Hill, 2005.

INSTITUTE ELECTIVE

L	T	P	C

CECS175 AI/ML BASED APPLICATIONS IN CIVIL ENGINEERING 3 0 0 3

CE XXX Scheme

1. **Course Outcomes (COs):**

At the end of the students will be able to:

CO1	Comprehend the basic principles of artificial intelligence (AI) and machine learning (ML) algorithms.
CO2	Understanding Data collection & management tools & techniques for AI/ML application to Civil Engineering.
CO3	Derive the need and benefits of using AI/ML algorithms for developing applications in Civil Engineering using big-data analysis.
CO4	Solve the real-life problems in Civil Engineering using real-time data collection and big-data analysis involving AI/ML tools.
CO5	Evaluate the performance of different AI/ML algorithms towards a given application in civil engineering.

Course Objective	Program Specific Outcome			Program outcomes		
	PSO1	PSO2	PSO3	PO1	PO2	PO3
1	3	3	3	3	3	3
2	3	2	2	3	2	3
3	3	3	3	3	3	3
4	3	2	3	3	3	3
5	3	3	3	3	2	3

Note: 1: Slightly 2: Moderately 3: Substantially

2. **Syllabus:**

Introduction to Machine Learning **(8 hours)**

Machine Learning Basics: Data Collection, Data Management, Big data, taxonomy of machine learning algorithms, **Supervised Learning:** Classification – Bayesian Classifier, K-nearest Neighbours, Regression- Linear Regression, Multivariate Regression, Logistic regression. Support Vector Machine (SVM) Algorithm. **Unsupervised Learning:** Clustering- K-means clustering algorithm and Hierarchical clustering algorithm. **Reinforcement Learning:** Q-Learning algorithm.

Data Collection Apparatuses **(8 hours)**

Type of data sources, Types of data, Types of sensors, Edge-devices, Introduction to microcontrollers, data communication protocols, Cloud storage and cloud computing, Local server setup, Cloud server setup, Introduction to Python, Introduction to Django server, Database setup.

Applications in Civil Engineering **(15 hours)**

Intelligent Transportation systems, smart mobility, shared mobility, Mobility as a Service (MaaS), Real-time data monitoring, Structural health monitoring, Fire resistance evaluation of structures, automation in water resource management, Water quality monitoring, water distribution system monitoring, air and noise pollution monitoring, Rainfall-runoff modelling, Climate change monitoring, Soil liquefaction, Forecasting foundation related parameters, Building occupancy modelling, Building information modelling, Energy demand prediction, Predictive maintenance of equipment, roads and buildings

APPLICATION PART I: Data Collection and Management **(7 hours)**

Image processing for real time applications in Civil Engineering, Description of available database across specialisations, Selection of sensors and microcontroller, Integration of sensors with Edge-device, Programming of Edge-devices, Programming of server in Django framework, Collection of sensor data and storing to Database, Cloud computing

APPLICATION PART II: Big Data Analysis **(7 hours)**

Selecting the appropriate ML algorithm for analysis, Data Processing, Analysing the importance of each variable in decision making, and Analysis of processed data,

(Total Contact Hors: 45)

3. <u>Books Recommended:</u>

1. *Machine Learning using Python,* by Manaranjan Pradhan, U Dinesh Kumar, Wiley.
2. *A Primer on Machine Learning Applications in Civil Engineering,* by Deka P C, Taylor & Francis.
3. *Structural Health Monitoring: A Machine Learning Perspective,* by Charles R. Farrar, Keith Worden, Wiley.
4. *Building Blocks for IoT Analytics,* By John Soldatos, Athens Information Technology, Greece, River Publishers.
5. *Django - The Easy Way (2nd Edition)*, By Samuli Natri.
6. *The Django Book (Release 2.0)*, By Adrian Holovaty, Jacob Kaplan-Moss, et al., 2013.
7. *Benjamin J. R., Cornell C. A., Probability Statistics and Decision for Civil Engineers, McGraw-Hill, 1970.*
8. Simon P. Washington, Matthew G. Karlaftis, Fred, Mannering L., *Statistical and econometric methods for transportation data analysis*, CRC Press, Second Edition, 2010.
9. Richard A. Johnson, Dean W. Wichern, *Applied Multivariate Statistical Analysis*, Prentice Hall, 1992.

4. <u>Other Material:</u>

1. *Arduino-ESP32 (Release 2.0.2)*, Espressif, 2022.

M. TECH. I (TEP) SEMESTER- III **L T P C**

CETP295 DISSERTATION PRELIMINARIES **0 0 26 13**

CO1: Compose a problem statement in advanced areas of transportation engineering based on review of relevant literature

CO2: Formulate objectives and scope based on identified research gap and need

CO3: Develop comprehensive methodology including tools & techniques to be used

CO4: Design the experiments : filed/ laboratory / simulation to build necessary data base to meet out the framed objectives of research

CO5: Prepare the detailed report and presentation so as to demonstrate written and oral communication skills.

Course Objective	**Program Specific Outcome**			**Program outcomes**		
	PSO1	**PSO2**	**PSO3**	**PO1**	**PO2**	**PO3**
1	2	3	2	3	2	3
2	3	3	3	3	2	3
3	2	3	3	3	2	3
4	3	3	3	3	1	3
5		2	1		3	3

Note: 1: Slightly 2: Moderately 3: Substantially

Dissertation preliminaries should clearly identify the goals & objectives and scope of the dissertation work taken up by the candidate. The focus is on data identification and proposed field surveys, questionnaire design, sample size decision. The study methodology and literature review on the dissertation topic is to be completed and a typed report is to be finalized in consultation with dissertation supervisor and submitted for the assessment at the end of the semester.

M. TECH. I (TEP) SEMESTER- III **L T P C**

SUMMER TRAINING **0 0 0 1**

CO1	Get acclimatized with the work culture in an industry/research organization towards meeting deadlines and punctuality.
CO2	Apply the knowledge gained from traffic engineering, highway design and construction, and transportation planning to solve real field problems.
CO3	Examine the real field conditions using the relevant concepts studied during the course work.
CO4	Compile the information in connection with the task accomplished during the internship in the form of a report.

Course Objective	**Program Specific Outcome**			**Program outcomes**		
	PSO1	**PSO2**	**PSO3**	**PO1**	**PO2**	**PO3**
1	3	2	1	1	0	1
2	3	3	2	3	1	3
3	3	3	3	3	1	3
4	3	2	2	1	3	1

Note: 1: Slightly 2: Moderately 3: Substantially

Six/Eight-week summer training on major Transportation or Traffic project, is to be carried at National/State/Local Government Project level after the Second Semester Examination and prior to opening of Third Semester and project report on the same is to be prepared & submitted duly certified by the Project Organization.

M. TECH. I (TEP) SEMESTER- IV **L T P C**

CETP296 DISSERTATION **0 0 40 20**

CO1: Plan the investigations and build adequate data base for fulfilment of the set objectives.

CO2: Analyze the data using suitable technique(s) to draw relevant inferences

CO3: Develop the mathematical / empirical / simulated model using analytical tool(s)

CO4: Organize the research work to prepare dissertation report as per the prescribed format.

CO5: Defend the research work through power point presentation demonstrating comprehensive understanding of the problem and research inferences

Course Objective	Program Specific Outcome			Program outcomes		
	PSO1	PSO2	PSO3	PO1	PO2	PO3
1	2	3	2	3	1	3
2	3	3	3	3	1	3
3	3	3	3	3	1	3
4	1	1	1	1	3	3
5	2	2	2	2	3	3

The preliminary dissertation work initiated in Third semester is further extended over fourth semester to cover up the field studies, data analysis, modeling, if any and research finding followed by conclusion etc.

The main objective of the dissertation work is to provide scope for original & independent research to express the ability of using analytical approach or technical investigation.

Thesis is to be prepared by each student under the guidance of faculty supervisor and finally submitted in six typed bound sets as per the specified time.

The assessment of the dissertation work will be carried out in two stages, first during the semester for 160 marks, and final viva-voce exam for 240 marks at the end of the semester.

Teaching and Examination Schemes with Syllabus

of

Master of Planning

in

Urban Planning

(Effective 2024-25)

(Approved by the SEC of Senate dated --------------)

Department of Civil Engineering
Sardar Vallabhbhai National Institute of Technology, Surat

Vision and Mission of the Institute

Vision

To be one of the leading Technical Institutes disseminating globally acceptable education, effective industrial training and relevant research output

Mission

To be a globally accepted centre of excellence in technical education catalyzing absorption, innovation, diffusion and transfer of high technologies resulting in enhanced quality for all the stake holders

Vision and Mission of the Department

Vision

To be a global centre of excellence for creating competent professionals in Civil Engineering

Mission

- To provide excellent education producing technically competent, globally employable civil engineers who will be leaders in the chosen field
- To undertake research in conventional and advanced technologies fulfilling the needs and challenges of modern society
- To provide consultancy services and develop partnerships with society, industry and public organizations.
- To organize seminar, conferences, symposia and continuing education programmes for academic and field community.

Foreword

India is transitioning from a mostly rural to a quasi-urban country. This poses challenges for sustainable development and at the same time presents a great opportunity for leveraging the benefits of urbanization with robust systems in place. This is a crucial time to leverage technology, and ensure planned development that can bring in greater economic and social benefits across the country. Urban planning, which is the foundation for the integrated development of cities, citizens, and the environment, has to be given adequate attention. Keeping in view all the necessities, there is an urgent need for a multi-sectoral approach to spatial planning as sectoral schemes are executed by different government departments and often not linked with each other. This is certainly not possible without adequate technical knowhow and planning capacities at the local levels. This further necessitates a stronger urban planning ecosystem in the country. Looking to this, course was initiated as Maters in Town and Regional Planning in 1987.

The first program of Master in Town and Regional Planning started in the year 1987 was renamed as Master of Engineering (Civil) in Town and Regional in 1991, Master in Town and Regional Planning in 2002, Master of Technology in Civil Engineering (Town & Regional Planning) in 2004, M. Tech in Planning in 2005, M. Tech in Urban Planning in 2010. The intent of this Program is to educate the students in high level knowledge acceptable at global level enabling them to face field problems of urban and regional planning.

M. Tech Urban Planning Course curriculum involves core subjects as Urban Planning Fundamentals, Traffic and Transportation Planning, Urban Governance and legislation, Urban Infrastructure Planning and Management, Housing, etc. and Elective Subjects as Geospatial Techniques, Regional Planning, Real estate management, etc. Elective subjects are introduced to manage recent happenings and advancement in field of Urban Planning and also helpful in attaining POs.

After completing the 2 years course, graduates may start working as professional planners for Government or Private enterprises and setups.

Planners have diverse job opportunities available in front of them. The graduates have access to both Government as well as Private sector job opportunities. Government Departments related to Urban and Town planning at Central and State level, Government operated Housing schemes, Government Transportation Projects (Highways, Railways and Metros etc), Government Construction and rehabilitation projects, PWD Projects, Municipal Corporation and ULBs are well known Government job opportunities. Government agencies taking care of above mentioned and/or similar services are known to recruit planning professionals. Self-employment opportunities are also available in front of planning professionals. Starting a consultancy service is the first thing that comes to my mind, talking about self-employment.

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Programme Educational Objectives (PEOs)

The graduates of the M. Tech. Urban Planning Programme will:

PEO1: To develop strong understanding of fundamentals in urban and regional planning with the necessary theoretical background, technical skills and knowledge of government policies to work professionally in the area of urban planning.

PEO2: To prepare students for successful career and technical knowhow with the values and social concern to meet the requirements at National and International levels.

PEO3: To provide exposure to the students in emerging technologies, software, adequate training and opportunities to work on research problems with effective skills.

PEO4: To train the students with effective communication skills and leadership to impart professional and ethical practices to function within multidisciplinary framework.

Programme Outcomes (POs)

The outcomes of the Master of Technology programme in Urban Planning are:

PO1: An ability to independently carry out research /investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/document.

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

Programme Specific Outcomes (PSOs)

- PSO-1: Demonstrate sound knowledge in analysis, design, studio investigations and planning aspects of town / urban / region to deal with various professional matters and provide community acceptance, environment-friendly and sustainable solutions.

- PSO-2: Have a broad understanding of economical, environmental, societal, health and legislative factors involved in planning and design to function within multidisciplinary framework.

- PSO-3: Be motivated for continuous self-learning in urban planning practice and/or pursue research in advanced areas of urban planning in order to offer services to the society, ethically and responsibly.

Teaching Scheme
M. Tech. in Urban Planning

Sr. No.	Subject	Code	Scheme L-T-P	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
				Th.	T	P		
				Marks	Marks	Marks		
	First Semester							
1	Urban Planning Fundamentals	CEUP101	3-0-0	100	-	-	3	65
2	Traffic and Transportation Planning	CEUP103	3-0-0	100	-	-	3	65
3	Housing	CEUP105	3-0-2	100	-	50	4	65
4	**Core Elective - 1**	##	3-0-0	100	-	-	3	50
5	**Core Elective - 2**	##	3-0-0	100	-	-	3	50
6	Professional Practice -I	CEUP107	0-0-4	-	-	50	2	65
7	Professional Practice -II	CEUP109	0-0-4	-	-	50	2	65
						Total	**20**	**425**
8	Vocational Training (optional) (Mandatory for Exit)	CEUPV93	0-0-10	-	-	-	5	200 (20 x 10)
	Second Semester							
1	Urban Planning Techniques and Practices	CEUP102	3-0-0	100	-	-	3	65
2	Urban Infrastructure Planning	CEUP104	3-0-0	100	-	-	3	65
3	Urban Governance and Legislation	CEUP106	3-1-0	100	25	-	4	65
4	Core Elective - 3	##	3-0-0	100	-	-	3	50
5	Institute (Open) Elective[#]	##	3-0-0	100	-	-	3	50
6	Professional Practice - III	CEUP108	0-0-4	-	-	50	2	65
7	Professional Practice - IV	CEUP110	0-0-4	-	-	50	2	65
						Total	**20**	**360**
8	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	##	0-0-10				5	200 (20 x 10)

Sr. No.	Subject	Code	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
			Th. Marks	T Marks	P Marks		
	Third Semester						
1	MOOC course-I*	CEUP 201	#	#	#	3/4	70/80
2	MOOC course-II*	CEUP 203	#	#	#	3/4	70/80
3	Design Portfolio	CEUP 205	-	-	100	02	65
4	Summer Training**	CEUP 207	-	-	100	-	70
5	Dissertation Preliminaries	CEUP 295	-	-	350$	14	560
			Total			**22-24**	**770-790**
	Fourth Semester						
1	Dissertation	CEUP296	-	-	600$	20	800

$ **Internal**: 40% and **External**: 60%

** Non Credit Audit Course

*Swayam/NPTEL

#To be offered to the PG students of other department and other PG Programs with the department

Core Elective 1

CEUP 111 Urban Land Management
CEUP 113 Rural Planning and Development
CEUP 115 Technical & Professional, Writing & Communication
CETP XX Research Analytical Methods
CEUP 117 Geospatial Techniques
CEUP 127 Swayam/NPTEL

Core Elective 2

CEUP 119 Building for Greater Efficiency
CETP xx Soft Computing Techniques
CEUP 121 Tourism Planning and Development
CEUP 123 Climate Change & Human Settlement
CEUP 125 Real Estate Management
CEUP 129 Swayam/NPTEL

Core Elective 3

CEUP 112 Planning Legislation
CEUP 114 Urban Economics & Sociology
CEUP 116 Regional Planning
CEUP 118 Urban Design and Landscape Development
CEUP 120 Planning & Development of Informal Sector
CEUP 122 Urban Dynamics
CEUP 124 Swayam/NPTEL

Institute Elective 3

CEUP172 Smart Cities Planning and Management
CECS230 AI/ML Based Applications in Civil Engineering

Total Credits: 82

Assessment of Performance

Assessment of Theory Courses

The evaluation pattern for the theory courses, *as of now*, shall be as under:

Mid-semester examination: 30 marks
Assignment/Quizzes: 20 marks
Tutorials (if applicable): 25 marks
End-semester exam: 50 marks

The mid- and end-semester examinations are of 1.5 hours and 3 hours, respectively.

Assessment of Dissertation/Projects

Internal assessment of 40% weightage and External assessment of 60% weightage by a panel of examiners.

For more details please refer to the institute website
https://www.svnit.ac.in/Data/Notice/AcademicRegulations2013-2014.pdf

List of Qualifying B.E. / B.Tech. Programmes for getting admission in the M.Tech. (Urban Planning):

Name of the Department	Name of the Program	Eligible UG degree	Degree Code as per CCMT 2021 list	Eligible GATE subject	GATE subject code
Department of Civil Engineering	M. Tech. (Urban Planning)	B.E./B.Tech. Civil Engg.	(T118)	Civil Engineering	CE
		B.E./B.Tech. Transportation Urban Planning	(T185)	Civil Engineering	CE
		Bachelor of Architecture	(A401)	Architecture and Planning	AR
		Bachelor of Planning	(A402)	Architecture and Planning	AR
		B.E./B.Tech. in Architectural Engineering	(T106)	Architecture and Planning	AR
		B.E./B.Tech. in Architecture	(T107)	Architecture and Planning	AR
		B.E./B.Tech. in Building and Construction Technology	(T114)	Civil Engineering	CE
		B.E./B.Tech. in Civil Environmental Engineering	(T119)	Civil Engineering	CE
		B.E./B.Tech. in Planning	(T171)	Architecture and Planning	AR
		B.E./B.Tech. in Town planning	(T183)	Architecture and Planning	AR
		B.E./B.Tech. in Architecture and Regional Planning	(T193)	Architecture and Planning	AR
		B.E./B.Tech. in Civil Engineering and Planning	(T208)	Civil Engineering	CE
		B.E./B.Tech. in Civil Technology	(T209)	Civil Engineering	CE
		B.E./B.Tech. in Town and Country Planning	(T322)	Architecture and Planning	AR
		B.E./B.Tech. in Civil and Transportation Engineering	(T324)	Civil Engineering	CE
		B.E./B.Tech. in Architecture and Interior Decoration	(T332)	Architecture and Planning	AR
		B.E./B.Tech. in Civil and Transportation Technology	(T336)	Civil Engineering	CE
		B.E./B.Tech. in Civil Engineering (Public Health Engineering)	(T337)	Civil Engineering	CE
		B.E./B.Tech. in Urban and Regional Planning	(T383)	Architecture and Planning	AR
		B.E./B.Tech. in Civil and Infrastructure Engineering	(T425)	Civil Engineering	CE

Course-wise Detailed Syllabus

SEMESTER – I

CEUP101 URBAN PLANNING FUNDAMENTALS

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understand town planning concepts and theories.
CO2	Recognize the concepts for different area planning.
CO3	Identify different growth patterns and models.
CO4	Implement different guidelines, norms, land use planning policies, and survey techniques.
CO5	Develop various premises of different scales using the principles of urban planning.

2. Syllabus

- **EVOLUTION OF TOWN PLANNING** **(10 Hours)**

  Evolution in planning and physical form, Concept of urban human settlement, Differentiation between rural and urban settlement, concept of town, Evolved and Created Town Characteristics, Features of urban planning process, Role of urban planner, Genesis of urban form; Social, Geographical and Cultural impacts, Contemporary developments in planning, Impacts of Industrial revolution on town and regional planning, Contribution of eminent Planners: Lewis Mumford, Ebenezer Howard, Patrick Geddes, Sir Arthur Clarence Perry, Charles Correa, Le-Corbusier.

- **URBANISATION:** **(09 Hours)**

  Demography and Census Statistics- Significance of Census and Demographics- Planning policies framed based on Census-Use of Census Data in Urban Planning Rural and urban Migration, impacts of urbanisation, socio – economic impacts of growth of population, Social and Economic Environmental Administrator, Levels of Urbanisation, Indian scenario - Issues and Policies, Global scenario, Future trends of urbanization - Impact of Government Policies on Urbanization

- **GROWTH PATTERNS:** **(06 Hours)**

  Elements of town structure, Town classification: Functional and geographical; City Centre, Walled city and Urban Fringe areas; classification based on socio-cultural characteristics, changes with time and growth, growth theories, Characteristics of the urban environment and its components, land use, Modern urban forms. Peri- Urban Areas- Urban Fringe- Issues.

- **URBAN LAND USE PLANNING:** **(08 Hours)**

  Objectives and Principles of Urban planning; Different Land use planning norms, Environmental aspects of land use planning, Role of URDPFI guidelines in Town planning, Land use Structures, demand and supply of land relationship, Government policies of urban development, Role of Professional bodies

- **PLANNING SURVEYS:** **(08 Hours)**

Objectives, types, significance, Methodology, analysis, and applications; Researches through planning surveys; Use of planning surveys in Urban Modelling like Multiple Linear Regression Analysis; Planning parameters, aims, objectives, principles, Methodology and systems approach, environmental parameters.

- **AREA PLANNING** **(04 Hours)**

  Concept of Neighborhood Planning, Satellite Towns, Government Policies for small and medium towns, Urban and Rural Planning Rural-Urban Fringe

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(Total Lectures: 45 Hours)

3. References

1. Gallion A., Eisner S., (2005), "The Urban Pattern: City planning and design", CBS Publishers and Distributors Pvt. Ltd, Delhi.
2. Rishma A., "Town Planning in Hot Cities", Mir Publishers, Moscow.
3. Ward S., (2002), "Planning the 20th Century City" John Willer & Sons.
4. Shivramakrishnan K. C., (2011), "Revisioning Indian Cities", Sage Publications
5. F. S. Hudson, Macdonald and Evans Ltd. Estover, (2002)'Geography of Settlements', Plymouth

4. CO-PO-PSO_Mapping

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	1	0	2	1	2	1
CO2	1	0	2	2	2	1
CO3	2	0	2	3	2	2
CO4	3	2	3	1	3	2
CO5	3	3	3	3	2	3

CEUP103 TRAFFIC AND TRANSPORTATION PLANNING

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Distinguish the concept of urban transport scenario, traffic characteristics, and transport development
CO2	Understand the concept of urban mobility, terminals and logistics
CO3	Practice urban transport planning and modelling with use of Software
CO4	Apply the knowledge of traffic planning, management techniques, and design elements
CO5	Prepare short and long terms transport plans for current challenges in present and future cities.

2. Syllabus

- **TRAFFIC CHARACTERISTICS: (06 Hours)**
  Definition, concepts, Scope and utility of transportation engineering Traffic growth, major traffic studies, traffic problems, urban road cross section elements and Inter-sections, IRC Standards. Pedestrian movements and problems.
- **TRAFFIC PLANNING AND MANAGEMENT: (05 Hours)**
  Traffic planning parameters, geometrical requirements, design speed capacity, Traffic planning of identified areas - terminals, town centre, station area, CBD area. Regulation & control, Inter section traffic control, other management techniques.
- **DESIGN ELEMENTS: (07 Hours)**
  Design of Transport Infrastructure like Intersection Design, signal design, parking space design, etc.
- **TRANSPORT DEVELOPMENT: (07 Hours)**
  Transport Development - Importance of Transport Development -Growth of rail and road transport, Investment in transport sector over time. Role of transportation in national and regional development, Transport infrastructure projects.
- **URBAN TRANSPORT PLANNING AND MODELING: (06 Hours)**
  Fundamentals of transportation system planning, Principals of urban transport, scope and content of comprehensive transportation planning, basic steps of transport planning: Trip generation, distribution, modal split & route arrangement. Use of various software for transport planning and modelling.
- **MASS TRANSPORTATION PLANNING: (08 Hours)**
  Basic system of urban transportation, Para transit system, planning of city bus transportation, BRTS, Metro transport system, Urban Mobility: Issues and Concepts, Feeder Services for Public Transport-Integration of Informal and Mass Transportation
- **TERMINALS AND LOGISTICS: (06 Hours)**
  Types and facilities, location, layout plan, function, activity planning guideline and land requirement for Bus Station, Railway Station & Airport – Logistics- Definitions- Location Aspects of Logistics Park.

(Total Lectures: 45 Hours)

3. References

1. Kadiali, L.R.,(2019), “Traffic and Transportation Planning”, Khanna Publishers, Delhi.
2. Papacoster, C.S. and Prevendons, (2002), “Transportation Engineering and Planning” Prentice Hall of India.
3. Morlok, K.E., (2002), Introduction to Transportation Engineering, McGraw-Hill, New York
4. Bernard Favre (2014) ‘Introduction to Sustainable Transport’
5. Kevin J. Krizek and David A. King (2021) ‘Introduction to Urban Transport Planning’

4. CO-PO-PSO_Mapping

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	0	2	1	2	1	1
CO2	0	1	0	2	1	1
CO3	2	2	3	3	0	3
CO4	3	1	3	3	3	3
CO5	3	3	3	3	3	3

CEUP105 HOUSING

L	T	P	C
3	0	2	4

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understand the housing forms and their relationship with urban areas.
CO2	Review the policies, norms, bylaws, and housing schemes in the Indian context.
CO3	Discuss housing scenarios, housing finance, the housing market, and the role of stakeholders
CO4	Compare housing typologies in the context of different climatic conditions
CO5	Design and plan residential areas considering socio-economic factors.

2. Syllabus

- **PLANNING OF RESIDENTIAL AREAS:** (**10 Hours**)

  Household and housing, housing requirement for different sections of society, building byelaws, development controls, housing projects layouts, Neighbourhood planning, design standards and their significance in housing process, socio-economic and aesthetic, environmental factors affecting layouts, various concepts of layout planning, row and multi storied housing, layout optimization techniques, appropriate DU design.

- **HOUSING FOR URBAN POOR:** (**09 Hours**)

  Process of slum formation, causes and consequences, approaches to tackle the Challenge of slums. Housing Evaluation for urban Poor, Aerial and cluster standards, materials, social amenities and services, locational parameters, Policies. Housing schemes, relocation, rehabilitation, in-situ upgradation, etc.

- **HOUSING POLICIES & FINANCE:** (**12 Hours**)

  Housing policies, Co-operative housing, Role of Central, State, Urban Local Bodies private and public sectors. Roles of financing institutes, Housing Boards, HUDCO, NHB, HFIs, various international donor/financing agencies, micro finance institutions, rural housing finance.

- **HOUSING MARKETS:** (**08 Hours**)

  Concepts and definitions of housing market, area, the purpose and nature of housing market studies; factors affecting housing prices, housing market behaviour, estimation of housing need, housing demand ,The formal and informal housing markets and their impact on urban poor, public, Co-operative and private sector.

- **CASE STUDIES:** (**06 Hours**)

  Case studies of housing projects at National and International Level, Housing for different climatic conditions, institute housing, Mass Housing, Affordable Housing, Transit and Temporary Shelters, Integrated Housing Schemes energy efficient design, Methodology for formulation of housing projects.

(Total Lectures: 45 Hours)

3. References

1. Dwivedi R. M., (2007), “Urban development and housing in India 1947-2007” New Century Publications, New Delhi.

2. James A. LaGro Jr. (2008), “Site Analysis A Contextual Approach to Sustainable Land Planning and Site Design”, John Wiley and Sons,Inc., Hoboken, New Jersey
3. Khanna P. N., (2019), “Indian Practical Civil Engineers Handbook”, Engineers Publishers
4. Goswami D., (2012), “Housing and Urban Poverty Alleviation”, SAAD Publications, Delhi
5. Kishor C. (2008), “Informal Sector: Concept, Dynamics, Linkages & Migration”, Concept Publishing Company, New Delhi.

4. CO-PO-PSO_Mapping

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	1	0	1	1	2	1
CO2	1	2	2	1	3	1
CO3	2	1	2	2	3	2
CO4	2	1	2	3	3	2
CO5	3	3	3	3	3	3

CEUP107 PLANNING STUDIO - I

L	T	P	C
0	0	4	2

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Calculate the space and area requirement for different area planning as per guidelines and norms
CO2	Understand the fundamentals of plan preparation and approval.
CO3	Conduct perception study of neighbourhood
CO4	Identify and present the planning issues with stake holders consultations
CO5	Prepare area-based plan at neighbourhood scale and their implementation strategies.

2. Syllabus

- **STUDIO ON AREA PLANNING**

  The Project on Housing includes study of housing layouts for different economic classes, different building forms, preparing lay-out plans of neighbourhood incorporating field studies and familiarization with site development standards, zoning and subdivision regulations. Assessment of existing project, and preparation of housing plans and Neighbourhood plans.

  The objective of this exercise is to evolve comprehensive housing development strategy for the selected city by studying city level and housing subsystem level aspects and estimating housing shortage; projecting housing need and demand and preparing alternative scenario's for housing development.

- **PLANNING STUDIO WORK:**

a. Undertake studies and surveys for Site selection, site analysis, technical feasibility studies, for formulating the project and design of selected area / project.
b. Undertake studies to assess management, financial feasibility, Cost Benefit Analysis of Project, Social and Economic Impacts of Various Projects,
c. Identify bottle-necks and prepare proposals suitable for implementation of Projects in consultation with between Planning Authority and Stake Holders

The studies need to be carried out mainly through secondary sources. A field visit to any town/city in India has to be made. The students are required to submit typed report (A4 Size paper spiral bound, 2 copies) along with studio exhibits (imperial size drawing sheet) for both the projects. The work shall be carried by the project team and to be presented to the panel of examiners including one external examiner.

(Total Contact Hours: 60 Hours)

3. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	1
CO2	1	3	1	1	3	1
CO3	1	1	1	2	2	1
CO4	2	1	2	3	2	3
CO5	3	2	3	3	3	3

CEUP109 PLANNING STUDIO - II

L	T	P	C
0	0	4	2

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understand the travel demand for the study area
CO2	Calculate the demand and supply for the given area as per guidelines and norms
CO3	Comprehend the concepts and practical aspects on urban mobility and road safety audit
CO4	Develop transportation infrastructure plan in all aspects for passengers and logistics
CO5	Prepare transport/ traffic management plans and their implementation strategies.

2. Syllabus

- **TRAFFIC/TRANSPORTATION PLANNING PROJECT.**
  The project on Traffic /Transportation planning covers study of Traffic & Transportation Planning of the City / Urban Area including hierarchy of roads, Planning parameters, problem identification and solutions at city/ zonal /local level, intersections designs, logistic parks, bus/ rail terminal studies, road safety audits etc.
- **PLANNING STUDIO WORK:**

a. Undertake studies and surveys for Site selection, site analysis, technical feasibility studies, for formulating the project and design of selected area / project.
b. Undertake studies to assess management, financial feasibility, Cost Benefit Analysis of Project, Social and Economic Impacts of Various Projects,
c. Identify bottle-necks and prepare proposals suitable for implementation of Projects in consultation with between Planning Authority and Stake Holders

The studies need to be carried out mainly through secondary sources. A field visit to any town/city in India has to be made. The students are required to submit typed report (A4 Size paper spiral bound, 2 copies) along with studio exhibits (imperial size drawing sheet) for both the projects. The work shall be carried by the project team and to be presented to the panel of examiners including one external examiner.

(Total Contact Hours: 60 Hours)

3. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	0	0	1	2	0
CO2	3	3	2	3	3	1
CO3	1	1	1	1	2	1
CO4	3	3	3	3	3	3
CO5	3	3	3	3	2	3

CORE ELECTIVE – 1

CEUP111: URBAN LAND MANAGEMENT

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understand the significance of Urban Land Management.
CO2	Understand Land as Resources and its related terminology.
CO3	Postulate dynamics of Urban Land market.
CO4	Identify legal aspects of development and their impacts on real estate development
CO5	Apply land management techniques to manage urban growth

2. Syllabus

- **LAND MARKET DYNAMICS: (10 Hours)**

  Concept, Scope, Principles, Land Use and Land Value, Parameters of Land dynamics market mechanism and land use pattern, Land Revenue Code, Land use restriction; compensation and acquisition, Urbanisation and land price speculations

- **LAND ECONOMICS: (08 Hours)**

  Economics and Principles of land use, Development of land and real properties, Land Development charges and betterment levy PPP in urban land development & case studies

- **LAND POLICIES AND PRACTICES AND TECHNIQUES: (16 Hours)**

  Policy: Concept, Need, Objective, Significance, Factor influencing location decision, Analysis of location of specific land use like residential-industrial commercial and institutional in intra regional as well as inter regional level Case studies of various land use policies and practices at national, state, district and settlement level, Land acquisition and land pooling techniques, Process of virgin agricultural land converted into fiscal Resources

- **LEGAL ASPECTS: (11 Hours)**

  Provisions of Land Acquisition Act, Urban Land Ceiling Act and Conservation Act, Town planning Acts, Origin, Objectives and applications. Building Bye-laws-Formations, Provisions and implications. Impacts on real estate developments.

(Total Lectures: 45 Hours)

3. References

1. Lall S. V. (2009), Urban Land Markets: Improving Land Management for Successful Urbanization, Springer.
2. Randolph J. (2012), Environmental Land use planning and Management,2nd ed, Island Press.
3. Berke P. R. (2009), Urban Land use Planning, 5th ed, Chicago: University of Illinois Press.
4. Deakin M.(2016), 'Meethodologies, Models and Instruments for Rural and Urban Land Management', Routledge

5. Christopher C, (2011), 'Growth Management and Public Land Acquisition: Balancing Conservation and Development', Routledge

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	0	0	1	1	1	0
CO2	1	0	1	1	1	1
CO3	2	2	2	2	2	1
CO4	3	1	3	2	3	2
CO5	3	3	3	3	3	3

CORE ELECTIVE – 1

CEUP113: RURAL PLANNING AND DEVELOPMENT

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understand the concept of rural planning and development
CO2	Interrelate the concept of agriculture development
CO3	Review national policies and technologies used in rural development.
CO4	Recognize institutions and organization setup of rural areas.
CO5	Perceive the concept of Rurban and related terminology.

2. Syllabus

- **INTRODUCTION:** **(06 Hours)**

  Introduction: Meaning and Scope and overview of rural development: Historical perspective – Rural Development Programmes in India. Problem / perception and identification; Rural Area Planning – Programmes / Policies / Schemes for rural development, their coverage and outcomes;

- **RURAL PLANNING AND DEVELOPMENT:** **(08 Hours)**

  Programme of Rural planning and developments, Backward Area Development Programme, North Eastern Development Programme. Impacts and Implications of Rural policies on rural and urban development. Planning of village centre. Planning and management of village clusters. Low cost

- **PROFILE OF RURAL SETTLEMENTS:** **(06 Hours)**

  Definitions need growth, distribution and classification of rural settlements, size from function and morphology of rural settlements.

- **RURAL SETTLEMENT ANALYSIS:** **(06 Hours)**

  Types, activity, environment and economic interface in rural habitat, technology in rural settlement; Mobility between rural and Urban Areas.

- **TECHNOLOGY FOR RURAL PLANNING AND DEVELOPMENT:** **(09 Hours)**

  Understating different missions, ICT in rural development, Rural Information system, Weather forecasting, disaster minimization, market information, etc. E-Panchayats, energy efficient technologies and alternative technologies

- **RURAL INSTITUTIONS AND ORGANISATIONS:** **(10 Hours)**

  Rural bank, Co-operatives, marketing and public administration Zila Parishad, Block Semity and Gram-Panchayat, powers and function of recently proposed Panchayat Raj Bill., Panchayati Raj Institution (PRI) Various Programs, Hierarchy of Panchayati Raj Institution, White revolution and Economy change in Rural development. Export promotion and SEZ Zones are identified in rural areas

(Total Lectures: 45 Hours)

3. References

1. Ramchandran H., Village Clusters and rural Development, Concept Publ. Co., New Delhi.

2. Planning Commission “Manual of Integrated District Planning 2006” Planning Commission, New Delhi
3. Government of India, “Various Five Year Plans (1st to 12th)” Planning Commission, New Delhi
4. Govt. of Kerala “Kollam Perspective Plan 2009” Department of Town & Country planning, Thiruvanantpuram
5. Cokke, B. and Kothari, U (Eds.) (2001), People’s Knowledge, Participation and Patronage, London: ZED Books.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	0	0	1	2	1	0
CO2	1	1	3	2	0	0
CO3	2	2	3	3	3	1
CO4	1	1	0	3	3	2
CO5	2	1	2	3	3	2

CORE ELECTIVE – 1

CEUP115 TECHNICAL AND PROFESSIONAL COMMUNICATION AND WRITING

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understand the Urban Planning Vocabulary and terminologies
CO2	Develop writing ability for a technical and professional report
CO3	Differentiate between technical, scientific, legal, and other types of communication
CO4	Find the information and sources which are relevant to the topic
CO5	Prepare and deliver an oral and technical presentation

2. Syllabus

- **URBAN PLANNING VOCABULARY** (**08 Hours**)

  Terms and words related to Planning, Professional vocabulary of Urban Planning, Conceptualizing theories, and Designing language.

- **TECHNICAL AND PROFESSIONAL WRITING** (**12 Hours**)

  Types and Classification of Reports Types of reports Specific characteristics of writing technical reports English comprehension and oral communication Format and Elements of Reports Preface, acknowledgments, contents, indexing, keyword indexing, introduction, body terminal section, appendices, References and bibliography Literature surveys: Use of libraries, knowledge of indexing and available reference materials.

- **PROFESSIONAL COMMUNICATION** (**05 Hours**)

  Different types of communication, its delivery, and effectiveness

- **LITERATURE RESEARCH** (**12 Hours**)

  Identify specific requirements for evaluation/review and what constitutes the completion of your work. Differentiate between journals, conferences, books, magazines, and their quality. Understand how to establish their quality and authenticity. How to conduct effective searches How to find relevant papers related to your area of research How to capture critical information. Compare ideas and concepts from different papers.

- **PRESENTATION SKILLS** (**08 Hours**)

  Designing and colour schemes, Effective visual infographics, Online templates, Confidence in delivery, Body Language.

(Total Lectures: 45 Hours)

3. References

1. Krista L. (2012), 'The Insider's Guide to Technical Writing', Ingram short title
2. Gerald A. (2011), 'Handbook of Technical Writing', St. Martin's Press

3. Natasha T. (2010), ‘Professional Writing Skills: A write it well guide’
4. Pravin B. (2001), ‘Professional Communication Skill’, S.Chand Publications
5. Paul A. (2017), ‘Technical Communication: A Reader- centered approach ’Wadsworth Publishing Co IncBhatta B.,”Remote Sensing and GIS”, Oxford University Press, New Delhi, 2008

4. CO-PO-PSO_Mapping

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	0	2	0	0
CO2	2	3	3	1	0	1
CO3	2	3	1	1	1	2
CO4	1	2	1	2	2	3
CO5	2	3	2	1	1	1

CORE ELECTIVE – 1

CETPxxx: RESEARCH ANALYTICAL MEETHODS

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understand the importance of the research process in a systematic way
CO2	Classify different types of data, its collection and presentation
CO3	Interpret the validity of a particular phenomenon.
CO4	Identify select the best possible alternative out of many options.
CO5	Judge the appropriate type of sampling and to find the required number of samples for a given population.

2. Syllabus

- **SOCIAL RESEARCH FORMULATION** **(09 Hours)**

  Design of research - Scaling techniques - Sampling design - Design of questionnaire - Data collection and statistical processing, variables, types of variables, scaling of variables, coding of variables in software tools.

- **STATISTICS & PROBABILITY CONCEPTS** **(09 Hours)**

  Various probability distributions & their applications - Parameter estimation - Hypothesis testing - Random variables - Method of maximum likelihood - Hypothesis testing to compare multiple population - Statistical quality control.

- **HYPOTHESIS TESTING** **(09 Hours)**

  Hypothesis testing, types of error in hypothesis, confidence interval, significance tests for comparing variances and means, tests with small and large samples, two-tail and one-tail student's t-test, analysis of variance (ANOVA), non-parametric tests (Chi-square test and Kolmogorov–Smirnov test), central limit theorem, practice with transportation data.

- **REGRESSION ANALYSIS** **(09 Hours)**

  Simple linear regression, residuals and variances, Assumptions, multiple linear regression, two stage regression, forward, backward and step-wise regression, residual analysis, correlation analysis, type of correlations, coefficient of correlation, Karl-Pearson's coefficient, multivariate data analysis, factor analysis, applications in transportation engineering, goodness-of-fit tests and curve fitting.

- **OPTIMIZATION TECHNIQUES** **(09 Hours)**

  Linear programming - Simplex method - Transportation model - Concepts of non– linear programming - Decision theories – Rules - Decision under uncertainty, Applications in Transportation Engineering.

(Total Lectures: 45 Hours)

3. References

1. Benjamin J. R., Cornell C. A., Probability Statistics and Decision for Civil Engineers, McGraw-Hill, 1970.

2. Kothari, C.R., Research Methodology: Method and Techniques, New Age International Publication, 2004.
3. Hines W. W., Montgomery D. C., Probability and Statistics in Engineering and Management Science, John Wiley and Sons, New York, 1990.
4. Sharma J.K., Operation Research: Theory & Applications, MacMillan India Ltd., 2000.
5. Bhandarkar P.L., Wilkinson T.S., Methodology & Techniques of Social Research, Himalaya Publishing House, 1991.
6. Simon P. Washington, Matthew G. Karlaftis, Fred, Mannering L., Statistical and econometric methods for transportation data analysis, CRC Press, Second Edition, 2010.
7. Washinton SP, Karlafits MG, Mannering F.L., Statistical and econometric method for transportation data analysis, 2nd addition, CRC Press, 2011.
8. Richard A. Johnson, Dean W. Wichern, Applied Multivariate Statistical Analysis, Prentice Hall, 1992.
9. Cooley, WW and Lohnes, RR, Multivariate Data Analysis, John Wiley, 1971.
10. Joseph F. Hair, Bill Black, Barry Babin, Rolph E. Anderson, Ronald L. Tatham, Multivariate Data Analysis, Prentice Hall; 2005.

4. CO-PO-PSO Mapping

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	2	3	3
CO2	3	2	3	2	2	2
CO3	3	3	3	3	3	3
CO4	3	3	3	3	2	3
CO5	3	2	3	3	3	3

CORE ELECTIVE – 1

CEUP117: GEOSPATIAL TECHNIQUES

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Summarize various techniques of data acquisition
CO2	Classify different data structures of remote sensing, GIS & GPS.
CO3	Analyze images based on supervised and unsupervised techniques.
CO4	Generate GIS database model using software
CO5	Use spatial data analysis techniques for Urban Planning applications.

2. Syllabus

- **INTRODUCTION:** (**02 Hours**)
  Introduction to GIS, Remote Sensing and GPS, Applications in various fields of engineering and planning

- **CONCEPTS AND FUNDAMENTALS OF REMOTE SENSING:** (**08 Hours**)
  Basics of Arial and Satellite Remote Sensing, Components of Remote Sensing, Principles of Remote Sensing, Energy Sources, Electro Magnetic Radiation (EMR), Electromagnetic Spectrum, Energy Interactions, Active and Passive Remote Sensing, Data acquisition, Remote Sensing Platforms, Satellites, Sensors.

- **IMAGE INTERPRETATION AND DIGITAL IMAGE PROCESSING:** (**08 Hours**)
  Fundamentals of Air photo Interpretation, Keys, Elements of Air photo Interpretation for Terrain Evaluation. Digital image processing, Enhancement of Image, Supervised and Unsupervised Analysis, Classification and Analysis, Ground Truth.

- **STRUCTURE OF GIS:** (**08 Hours**)
  Cartography, Geographic mapping process, Transformations, Map projections, Geospatial and Geomatics Data, Geographic Data Representation, Storage, Quality and Standards of Data, Database management systems, Raster and Vector data representation, Assessment of data quality, Managing data errors.

- **GIS DATA PROCESSING, ANALYSIS AND MODELLING:** (**08 Hours**)
  Raster and Vector based data processing, Queries, Spatial analysis, Quadrant counts, nearest neighbour analysis, Network analysis, Surface modelling, DTM, Case studies of GIS Applications.

- **GLOBAL POSITIONING SYSTEM:** (**04 Hours**)
  Concept, Components of GPS, GPS setup, Accessories, Segments-satellites & receivers, Case studies of GPS applications.

- **INTEGRATED APPLICATIONS:** (**03 Hours**)
  Case studies of Integrated application of RS, GIS and GPS in the field of Urban Planning and Regional planning, Water resources, Environmental studies, Transportation engineering and other civil engineering fields.

- **INTRODUCTION TO SOFTWARE (QGIS/ARCHGIS)** (**04 Hours**)

Introduction to the software and its interface, setting up coordinates, Georefrenceing, Basic drafting tools, Filling up attributes, Plotting of maps etc.

(Total Lectures: 45 Hours)

3. References

1. Lo C.P. & Yeung A.K.W. (2006), Concepts and Techniques of Geographic Information Systems, 2nd ed, Prentice Hall of India, New Delhi.
2. Reddy A. (2008), Remote Sensing and Geographical Information Systems, B.S. Publications, Hyderabad
3. Clarke, K.,(2001) Getting Started with Geographic Information Systems, Prentice Hall, New Jersy.
4. DeMers M.N. (2008), Fundamentals of Geographic information Systems, 4th ed, John Wiley & Sons, New York.
5. Kennedy M. (2002), The Global Positioning System & GIS: An Introduction, 2nd ed, Ann Arbor Press,

   Krista L. (2012), 'The Insider's Guide to Technical Writing', Ingram short title

4. CO-PO-PSO_Mapping

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	1	0	0	1	0	1
CO2	1	1	2	2	1	2
CO3	3	2	2	3	2	2
CO4	3	2	3	3	2	3
CO5	3	3	3	3	2	3

CORE ELECTIVE – 2

CEUP119: BUILDING FOR GREATER EFFICIENCY

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understanding of building typologies, climatology, historical planning and development
CO2	Review of sustainable building planning policies, implementation and innovative materials
CO3	Assessing the building performance by applying sustainable techniques
CO4	Evaluating residential and commercial building at neighbourhood level
CO5	Making business case

2. Syllabus

- **SUSTAINABLE PLANNING AND DEVELOPMENT:** **(04 Hours)**

  Fundamentals of sustainability; Historical planning and development; Vernacular Architecture; climatic zones and parameters; Environmental impact on building cluster; Norms, guidelines, codes and policies; Stakeholder's role

- **SUSTAINABLE BUILDING PLANNING:** (**06 Hours**)

  Fundamentals of passive planning and design, climatology, thermal comfort, visual comfort and acoustic comfort, Minimization of natural resource utilization, Environment protection, site planning, energy conservation through planning and modeling, building technologies, indoor air quality, barriers to implementation of sustainable building measures

- **GREATER EFFICIENCY:** (**10 Hours**)

  Role of envelope, day light, daylight simulation, electric lighting and occupant behavior, thermal mass and Heat flow, thermal load, thermal simulation, heating cooling and ventilation (HVAC), role of planning and alternative material for reduction of operational energy in the building, life cycle cost, Net zero, Grid free, water & energy plus, checklist for sustainability, greater efficiency recommendations for sustainable buildings

- **BUILDING PERFORMANCE ASSESSMENT:** (**15 Hours**)

  Concept, tools at international and national level, Energy code ECBC requirement, NBC, Recent researches on sustainable building development, assessment tools – Open source, licensed software for performance assessment and energy compliance, Case studies of residential and commercial buildings

- **GREEN SERVICES:** (**06 Hours**)

  Climate and effect of built environment, Impact of urbanization on sustainability, Circular Economy through water and drainage network, Zero waste management, radiation budget, surface water balance, effect of trees and microclimate, modification through greening

- **MAKING THE BUSINESS CASE:** (**04 Hours**)

Green building Evaluation Systems; LEED Certification; Green Certification, WGBC, GRIHA, IGBC, EDGE, ASSOCHAM and CPWD green rating, SBTool, process and certification

(Total Lectures: 45 Hours)

3. References

1. Wheeler S. M. (2004), Planning for sustainability: creating livable, equitable and ecological communities, 2nd ed, Routledge, Taylor and Francis group, New York.
2. Maiellaro N. (2001), Towards sustainable building, Kluwer academic publishers, Netherlands,
3. The Energy and Resources Institute, (2004) "Sustainable building design manual: Sustainable building design practices" New Delhi
4. Takahiko Hasegawa T. (2003), Environmentally sustainable buildings: challenges and policies, Paris: Organisation for Economic Co-operation and Development.
5. Glavinich T.E. (2008), Contractor's Guide to Green Building Construction: Management, Project Delivery, Documentation, and Risk Reduction, Wiley.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	0	2	2	2	2
CO2	2	2	3	3	3	3
CO3	2	2	3	3	3	3
CO4	2	2	3	3	3	3
CO5	3	3	3	3	3	2

CORE ELECTIVE – 2

CETPxxx: SOFT COMPUTING TECHNIQUES

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Appraise characteristics of real-world problem and select appropriate soft computing technique.
CO2	To solve the optimization problems using the genetic algorithm.
CO3	Identify vagueness in data and formulate appropriate fuzzy model.
CO4	Calibrate ANN model by adopting appropriate activation function, learning rule and training algorithm.
CO5	Formulate FL - ANN hybrid model for the given real-world problem.

2. Syllabus

- **GENETIC ALGORITHMS** **(12 Hours)**

  Goals of optimization - Comparison with traditional methods - Schemata – Terminology in GA – Strings, Structure, Parameter string - Data Structures – Operators - Coding fitness function – Algorithm - Applications.

- **FUZZY LOGIC** **(12 Hours)**

  Concepts of uncertainty and imprecision – Sets - Concepts, properties and operations on Classical sets & Fuzzy Sets - Classical & Fuzzy Relations - Membership Functions - Fuzzy Logic – Fuzzification - Fuzzy Rule based Systems – Fuzzy propositions - Applications.

- **ARTIFICIAL NEURAL NETWORKS** **(12 Hours)**

  Basics of ANN; Models of a Neuron – Topology: Multi Layer Feed Forward Network (MLFFN), Radial Basis Function Network (RBFN), Recurring Neural Network (RNN) – Learning Processes: Supervised and unsupervised learning. Error-correction learning, Hebbian learning; Single layer perceptrons - Multilayer perceptrons - Least mean square algorithm, Back propagation algorithm Applications.

- **HYBRID SYSTEMS** **(09 Hours)**

  Fuzzy neural systems – Genetic Fuzzy Systems – Genetic Neural Systems.

(Total Lectures: 45 Hours)

3. References

1. Timothy J.Ross, Fuzzy Logic with Engineering Applicatios, McGraw-Hill
2. Simon Haykin, Neural Netwroks, PrenticeHall
3. J.M. Zurada, .Introduction to artificial neural systems., Jaico Publishers
4. H.J. Zimmermann, Fuzzy set theory and its applications., III Edition, Kluwer Academic Publishers, London.
5. Suran Goonatilake, Sukhdev Khebbal (Eds), .Intelligent hybrid systems., John Wiley & Sons, New York, 1995.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	0	3	3	3	3
CO2	3	1	3	3	3	3
CO3	2	0	3	2	3	3
CO4	3	0	3	3	3	3
CO5	2	0	3	3	3	3

CORE ELECTIVE – 2

CEUP121: TOURISM PLANNING & DEVELOPMENT

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understand the concept of tourism planning and development in urban and regional scale
CO2	Assess the impact of sustainable tourism development on natural environment
CO3	Promote tourism for economic development of a country.
CO4	Practice modern techniques of tourism planning and development.
CO5	Develop Revenue generation techniques through Tourism planning

2. Syllabus

- **INTRODUCTION TO TOURISM:** **(10 Hours)**

  Definitions, scope, nature, classification and dimension, tourism as an industry, tourism in developed and developing world. Tourism as system, Demand and supply, Relationship between Tourism and Urban Development. Creation of Urban Space for recreation and tourism, Principles of Recreation, Leisure and Tourism. Nature and scope of a tourism plan- key issues and stages, data requirements, surveys, role of key players / stake holders in tourism policy and planning.

- **SUSTAINABLE PLANNING FOR TOURISM DEVELOPMENT:** **(15 Hours)**

  Natural resource assessment; Techniques of tourism potential analysis; Concept of Eco-tourism, Environmental threats and planning precautions. Concepts and parametric analysis; Integrated wildlife, Tourism multiplier and forecasting Methods: capacity building and carrying capacity planning for tourism projects, tourism and cultural and social change: Socio, Tourism infrastructure development, Tourism Project conception and preparation for project report.

- **TOURISM MANAGEMENT AND ECONOMICS:** **(10 Hours)**

  Management and Economics of tourism industry and development management. Tourism marketing - concept, techniques and strategies. GIS application in tourism development, policies and programme at National State and District level. Tourism planning case studies.

- **POLICIES AND PROGRAMMES:** **(10 Hours)**

  Tourism policies at various levels. Case studies: Indian Site, 7 Projects for Gujarat Tourism.

(Total Lectures: 45 Hours)

3. References

1. Hall, C. (2008). Tourism Planning: Policies, Process & relationship. Prentice Hall.
2. Gunn, C. (2009). Tourism Planning: Basics, Concepts, cases. France & Taylor Publication
3. Goeldner, C. and Ritchie J. (2009). Tourism: Principles, Practices, Philosophies. John Wiley & Sons
4. Planning Commission (2012). Working Group Report on Tourism (2012-2017). Govt. of India
5. Ministry of Tourism. (2011). Strategic Action Plan for Tourism in India. Govt. of India. Ministry of Tourism.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	0	0	0	1	0	0
CO2	2	3	2	2	3	2
CO3	3	1	3	2	2	2
CO4	3	1	3	3	2	3
CO5	2	3	2	3	3	3

CORE ELECTIVE – 2

CEUP123 CLIMATE CHANGE AND HUMAN SETTLEMENT

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understand climate change
CO2	Discussing the Mitigation strategies in various context
CO3	Reviewing policies and acts all over the world and in India
CO4	Plan climate responsive proposals for mitigating climate change
CO5	Evaluate the funding provided to support adaptation

2. Syllabus

- **UNDERSTANDING CLIMATE CHANGE: (08 Hours)**

  Greenhouse gases, Anthropogenic causes, Carbon Cycle, Global Warming, Urban Heat Islands International and national Efforts, UNFCC, Conference of Parties, Kyoto Protocol, IPCC, Intended Nationally Determined Contributions (INDC), Global Environment Facility (GFC), Clean Development Mechanism, Role of Human Settlements in climate change, Contribution to GHGs, Sectorial contributions, Sensitivity and Vulnerability of different sectors

- **CLIMATE CHANGE: MITIGATION AND ADAPTATION LINKAGES: (08 Hours)**

  Mitigation and adaptation strategies and linkages, Low Carbon Settlements, Mitigation and adaptation options in cities of developed and developing Nations, Principles for planning of mitigation and adaptation, Urban form and climate change.

- **USE OF SCENARIOS FOR CLIMATE CHANGE ADAPTATION: (06 Hours)**

  Use of future scenarios, Climate change and socio-economic scenarios, Barriers to use of scenarios and appropriate interventions.

- **CLIMATE CHANGE AND COASTAL SETTLEMENTS: (06 Hours)**

  Climate change and human settlements in low elevation coastal zones, estimating population and human settlement patterns in low elevation coastal zones, Adaptation to rising sea levels and consequences.

- **PLANNING FOR GREEN INFRASTRUCTURE: (06 Hours)**

  Role of green infrastructure in adapting climate change, Quantification of environmental functions of green infrastructure, Climate adaptation strategies and programmes of green infrastructure.

- **CLIMATE CHANGE MITIGATION AND ADAPTATION IN INDIA: (05 Hours)**

India's urban transformation and climate change risk exposure, National Action Plan on Climate Change, Sustainable Habitat Mission, Gaps, Mitigation and Adaptation Agenda for Indian Cities Module

- **FUNDING PROVISIONS TO SUPPORT ADAPTATION: (06 Hours)**

Funding for adaptation under UNFCC, Role of Official Development Assistance (ODA) in funding adaptation, Access to adaptation finance by urban stakeholders

(Total Lectures: 45 Hours)

3. References

1. Sabrina. D. (2020), 'Cities Leading Climate Action: Urban Policy and Planning', Routledge
2. Vivek.S. (2019), 'Urban Adaptation to Climate Change: The Role of Urban Form in Mediating Rising Temperature', Springer
3. Nadja. K. (2018), 'Nature-Based Solutions to Climate Change Adaptation in Urban Area', Springer
4. Diane.A. (2016), 'Responding to Climate Change in Asian Cities: Governance for a more resilient urban future', Routledge
5. Beth.S. (2019), 'Regenerative Urban Development, Climate Change and the common good', Routledge

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	0	0	0	0	1	0
CO2	1	0	2	1	2	2
CO3	1	1	1	2	3	1
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3

CORE ELECTIVE – 2

CEUP125 REAL ESTATE MANAGEMENT

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understand the concept and principles of real estate sector.
CO2	Identify the role of urban building industry.
CO3	Review urban land policy and its direct government action, legal and physical controls.
CO4	Explain the role of real estate in Urban growth and land dynamics.
CO5	Identify legal aspects of real estate development.

2. Syllabus

- **REAL ESTATE** **(15 Hours)**

  Terminology, Land Documentation, Land Revenue Records, Document Registration, City Survey Record, Land Registration Process, Property Card, Index concepts and characteristics; Urban real estate market problems, factors affecting real estate property, rights and interests; Contract law and real estate; Speculation in urban land; betterment and worsening.

- **ECONOMICS & LOCATION MODELLING** **(16 Hours)**

  Factors affecting different land uses such as residential, commercial, industrial, public and semi-public; Land value – Concept and factors affecting; Rent and modern theory of rent; Macro and Micro approaches of Location such as trade-off model and environment preference model.

- **URBAN LAND POLICY** **(14 Hours)**

  Contents, importance, objectives, measures, instruments for its implementation, direct Govt. action, legal and physical controls; Relationship between economic trends, land market and urban development.

  Modern Methods for Land Pooling; PPP Method for Land Pooling; Issues and strategies for Land Management.

(Total Lectures: 45 Hours)

3. References

1. Lean W., “Aspects of Land use Planning”, New Jersey: Gonthic Publications, 1982
2. Paul B.N., “Urban Land Economics”, London: The McMillan Press, 1997
3. Singh B., “Urban Infrastructure and Real Estate Management”, Surendra Publications, 2011
4. Barry Haynes, “Corporate Real Estate Asset Managements: Strategy and Implementation”, 2017

5. John. R., “Urban Planning and Real Estate Development”, 2003

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	0	0	0	1	0	0
CO2	1	0	1	2	1	1
CO3	1	2	2	2	3	2
CO4	2	1	1	3	2	1
CO5	2	2	2	2	2	2

SEMESTER – II

CEUP 102 Urban Planning Techniques and Practices

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explore Planning and Land management models prevailing across the country
CO2	Review Town Planning Acts, guidelines and process of preparation of Development plan and Town planning scheme
CO3	Classify different types of data and its collection methods
CO4	Develop key data analytics skillsets necessary to interpret and derive inferences from the relevant datasets available
CO5	Use Advance Techniques of Data Interpretation i.e., Big Data, Data mining, spatial analysis for Urban Planning Application

2. Syllabus

- **TOWN DEVELOPMENT PLAN: (06 Hours)**
  Introduction to Urban Growth models, Concentric Zone Model, Hoyt Model, Multiple Nuclei Model etc., Land Management Models, Needs, roles and objectives; Process of preparation; General Guidelines of Development Plan; Impact of Population density; study of existing development plans; various drawings of Development plan.

- **TOWN PLANNING SCHEME: (08 Hours)**
  Study of Planning Acts, Purpose of Town Planning Schemes; Methodology and legal aspects; Study of Existing Town Planning Schemes.

- **DATA FOR PLANNING AND SOCIO-ECONOMIC SURVEYS: (10 Hours)**
  Data requirements for urban and regional planning; Sources of primary and secondary data; Quantitative and Qualitative methods of data collection, Validity and reliability of data, Questionnaire design, measurement scales and their applications, sampling techniques, types of socioeconomic surveys; Self-surveys, interviews, mailed questionnaires and observer participation, focus groups etc.

- **DATA ANALYTICS IN PLANNING: (14 Hours)**
  Need for Data Analytics in Spatial Planning, Revision of basic statistical concepts, Data coding, data cleaning techniques, biases and errors in data, sample size calculation and sampling techniques, Correlation, autocorrelation and Regression analysis – linear, logit and spatial, clustering spatial and non-spatial data – HCT, K-means, fuzzy K-means, etc., Factor analysis (PCA), Introduction to Machine learning and Artificial Intelligence in Urban Planning, Big data landscape, Introduction to model building and data validation.

- **GEOSPATIAL TECHNIQUE IN URBAN PLANNING: (07 Hours)**
  Introduction to remote sensing, GPS and GIS, satellite data products and its use, Application of remote sensing and GIS in urban planning.

(Total Lectures: 45 hours)

3. Books Recommended

1. Modak N.V. and V.N. Ambdekar, "Town and Country Planning and Housing", Orient Longman Ltd., New Delhi. (1995)
2. Hiraskar G.K. "Fundamentals of Town Planning", Dhanpat Rai & Sons, Delhi (1993).
3. Kothari, C.R., "Research Methodology: Method and Techniques", New Age International Publication, (2004).
4. Shen Z., "Big Data Support of Urban Planning and Management", Springer International Publishing AG, (2018).
5. Artificial Intelligence: A Modern Approach, Stuart J. Russell and Peter Norvig, 3rd Edition, Prentice Hall, (2009).

4. Mapping of COs and POs

	PO1	PO2	PO3
CO1	1	2	1
CO2	1	2	1
CO3	2	3	3
CO4	2	2	3
CO5	2	3	1

0-Not related 1-Low 2-Moderate 3-High

5. Mapping of COs and PSOs

	PSO1	PSO2	PSO3
CO1	2	1	1
CO2	2	2	2
CO3	3	3	3
CO4	3	3	3
CO5	2	3	3

0-Not related 1-Low 2-Moderate 3-High

CEUP104 URBAN INFRASTRUCTURE PLANNING

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understand Urban Infrastructure fundamentals with practical application.
CO2	Review different norms and guidelines of municipal infrastructure.
CO3	Adobe the most suitable management techniques for the better maintenance of infrastructure in future growth.
CO4	Identify different shortcomings and challenges in the current practices.
CO5	Explore modern techniques and technology in place of conventional methods.

2. Syllabus

- **URBAN INFRASTRUCTURE PLANNING (05 Hours)**
  Data required for provision & planning of Urban Infrastructure, Types, Significance, impact on urban form, norms and financial aspects, public, private, SPV and PPP models in infrastructure provisions, infrastructure policy.
- **NETWORKS AND SERVICES SYSTEMS (06 Hours)**
  Urban services overview, classification and significance, concepts and theories for design and operation, components, interrelationship, requirements of appropriate technology, cost recovery, gap analysis.
- **WATER SUPPLY NETWORK (06 Hours)**
  City & Household Network Scenario, Norms, National Water Policy, Water Rights: excess and underutilization of water, role of community in water provision, water harvesting, privatization of water supply and its implications.
- **SEWERAGE NETWORK (06 Hours)**
  City & Household Network Scenario, Norms, Sewerage drainage, refuse collection, storage, recycling and disposal, minimum basic needs, formulation of objectives, norms and standards both for space allocation and quality control, Storm water Network.
- **SANITATION AND SOLID WASTE MANAGEMENT (06 Hours)**
  Types, Generation, collection system, transfer station location, Segregation, transportation, disposal, site selection, Effect of population density, Impact of Urban land use, Bio-medical waste and disposal, Policies and programs in the provision of sanitation at various level, Low-Cost Sanitation, city sanitation plan and state sanitation strategies, cost recovery in solid waste.
- **ELECTRICITY & COMMUNICATION NETWORK (06 Hours)**
  Planning for electrification, Current scenario, services and space standards of Transformers space standards for electricity networks, Space station Location, Street lighting requirements, Communication network requirement.
- **SOCIAL INFRASTRUCTURE (10 Hours)**
  Health and Education hierarchy, norms and location. Energy distribution, fire protection: requirements, norms and standards, planning provision, milk distribution system, Recreation & Open Space Planning in Social Infrastructure.

(Total Lectures: 45 Hours)

3. References

1. National Institute of Urban Affairs (2005). Status of water supply, sanitation, and solid waste management in the urban area.
2. Yigitcanlar, T. (2010). Sustainable urban and regional infrastructure development: technologies, application, and management. IGI Global publishing company.
3. CPHEEO (2013). CPHEEO Manual on Sewerage and Sewage Treatment Systems.
4. CPHEEO (2016).CPHEEO Manual on Municipal Solid Waste Management.
5. CPHEEO (2019).CPHEEO Manual on Storm Water Drainage Systems.

4. CO-PO-PSO_Mapping

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	0	0	0	1	1	1
CO2	1	1	2	1	3	1
CO3	3	1	3	2	2	3
CO4	1	2	1	2	3	2
CO5	3	3	3	3	3	3

CEUP106 URBAN GOVERNANCE AND LEGISLATION

L	T	P	C
3	1	0	4

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Classify Indian System of urban governance, organization structure and planning legislation.
CO2	Understand finance systems of ULB's and role of state and central government.
CO3	Review of constitutional amendments and their relevance to planning and plan implementation.
CO4	Identify ULB's role, functions for citizens including public administration.
CO5	Formulate and design scenarios for ULB's in context of governance, finance and administration.

2. Syllabus

- **OVERVIEW OF URBAN GOVERNANCE** **(06 Hours)**
  Definition, concepts, components, government and governance, hierarchy and structure, forms of governance, Indian Constitution, Planning Legislation-Acts and Amendments.
- **INDIAN SYSTEM OF URBAN GOVERNMENT** **(10 Hours)**
  Salient Features of Local Government System in India-historical overview; Commissions & Committees; Council of State ministers; All India Council of Mayors; Centre-State-Local Relationships, 73th & 74th Constitution Amendment Act, E-governance and M-governance.
- **URBAN LOCAL GOVERNANCE AND PARTICIPATORY PROCESSES** **(15 Hours)**
  Role of Municipal bodies, City/Urban development authority in urban development, its background, functions, powers, organizational structure, achievement and limitation, case studies, ULB interface with NGO's, other agencies.stakeholders' participation, roles and responsibilities, access to government by various stakeholders.
- **URBAN FINANCE** **(14 Hours)**
  Central and State; Taxation, Property Tax Administration – Valuation Assessment, Collection, Budget, Municipal Accounting, Municipal Audit – Concepts, Settlement of Audit Objectives. Urban fiscal reforms, municipal finance and urban inclusion, Sources of revenues and application of money; Equities; Loans; Debt financing; Municipal Bonds, land and non-land-based sources.

(Total Lectures: 45 Hours)

3. References

1. Mathur, O.P. and George, P. (2006). State Finance Commissions and Urban Fiscal Decentralization in India. NIPFP.
2. Ministry of Finance. (2011). Report of 13th Finance Commission Government of India. New Delhi.
3. Jayal, N.G. Prakash A. and Sharma P.K. (2006). Local Governance in India: Decentralization and Beyond. Oxford University Press, New Delhi.
4. Baud, I.S.A., and Wit, J. de. (2008). New Forms of Urban Governance in India: Shifts, Models, Networks and Contestations Sage, New Delhi.
5. Sharma A.K. (2004). Bureaucracy and Decentralisation, Mittal, New Delhi.

4. **CO-PO-PSO_Mapping**

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	0	1	0	1	2	1
CO2	0	0	1	1	2	1
CO3	1	1	2	2	2	1
CO4	2	0	2	2	3	2
CO5	3	3	3	3	3	3

CEUP108 PLANNING STUDIO - III

L	T	P	C
0	0	4	2

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Adopt various land management and aggregation models.
CO2	Plan and design Town Planning Schemes as per relevant act.
CO3	Formulate financial mechanism for the designed town planning scheme.
CO4	Provide urban infrastructure in the designed town planning scheme.
CO5	Asses of impact on Environment due to development projects.

2. Syllabus

- **OVERVIEW**

  One planning projects are required to be completed from the following areas.

  a) Preparation of T.P. Scheme
  b) Preparation of Urban Infrastructures for different Micro and Macro level plans

- **PLANNING STUDIO WORK**

  a) Undertake studies and surveys for Site selection, site analysis, technical feasibility studies, for formulating the project and design of selected area / project.
  b) Undertake studies to assess management, financial feasibility, Cost Benefit Analysis of Project, Social and Economic Impacts of Various Projects,
  c) Identify bottle-necks, and prepare proposals suitable for implementation of Projects in consultation with Planning Authority and Stake Holders

  The studies need to be carried out mainly through secondary sources. A field visit to any town/city in India has to be made. The students are required to submit typed report (A-4, size papers, spiral bound, 2 copies) along with studio exhibits (imperial/ A1size drawing sheet) for both the projects. The work shall be carried by the project team and to be presented to the panel of examiners including one external examiner.

(Total Contact Hours: 60 Hours)

3. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	0	2	2	1	2
CO2	2	3	2	3	2	2
CO3	1	3	3	1	3	1
CO4	2	2	3	1	2	3
CO5	3	3	2	3	3	3

CEUP110 PLANNING STUDIO - IV

L	T	P	C
0	0	4	2

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Calculate demand and supply of the required infrastructure on city level.
CO2	Prepare planning proposal for urban infrastructure with respect to Smart Cities/Future Cities.
CO3	Recommend different urban infrastructure management techniques.
CO4	Formulate financial mechanism considering implementation, operation and maintenance cost.
CO5	Identify the process of environmental impact assessment for the prepared proposal.

2. Syllabus

- **OVERVIEW**

  One planning projects are required to be completed from the following areas.

  a) Sustainable Environmental Planning
  b) Smart Cities Infrastructure & Services

- **PLANNING STUDIO WORK**

  a) Undertake studies and surveys for site selection, site analysis, technical feasibility studies for formulating the project and design of selected area/project.
  b) Undertake studies to assess management, financial feasibility, Cost Benefit Analysis of Project, Social and Economic Impacts of Various Projects
  c) Identify bottle-necks and prepare proposals suitable for implementation of Projects in consultation with Planning Authority and Stake Holders.

  The studies need to be carried out mainly through secondary sources. A field visit to any town/city in India has to be made. The students are required to submit typed report (A-4, size papers, spiral bound, 2 copies) along with studio exhibits (imperial/ A1size drawing sheet) for both the projects. The work shall be carried by the project team and to be presented to the panel of examiners including one external examiner.

(Total Contact Hours: 60 Hours)

3. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	3	1	2	2	1
CO2	3	3	3	3	3	3
CO3	3	2	3	3	3	3
CO4	2	3	3	2	3	2
CO5	2	2	1	1	1	1

CORE ELECTIVE – 3

CEUP112: PLANNING LEGISLATION

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Describe different legislations related to urban planning and policy.
CO2	Demonstrate the legal procedures for preparation and implementation of Regional Plans, Master Plans and Town Planning Schemes.
CO3	Illustrate the regulations for planning.
CO4	Explain the role of politics in planning
CO5	Review of constitutional amendments and their relevance to planning and plan implementation

2. Syllabus

- **PLANNING LEGISLATION AND POLICY FORMULATION AND APPRAISAL: (12 Hours)**

  Evolution; An over view of legal tools connected with Urban Planning and Development, Town and Country Planning Act, Improvement Trust Act, Urban Planning and Development Authorities Act – objectives, contents, procedures for preparation and implementation of Regional Plans, Master Plans and Town Planning Schemes. Various Acts related to urban governance, planning and development organizations, land resources, environment protection, and public participation in statutory planning process; Approaches of formulation of policies, appraisal of policies.

- **UNDERSTANDING OF LAW: (08 Hours)**

  Concepts, sources, terminologies, significance of law and its relationship to Urban Planning benefits of statutory backing for schemes - eminent domain and police powers; Indian Constitution: concept and contents; 73rd and 74th Constitution Amendment Act, provision regarding property rights.

- **CITY AND THE STATE: (08 Hours)**

  State as a manager of resources – property rights, norms and standards – Government market and market by Government – Regulatory State, Reforming State, and Rent Seeking State – their spatial implications; Development planning and the Indian state – Centralization, powerlessness and decentralization; spatial politics and competition; Politics of the State and bureaucracy; New State spaces, invited and contested spaces – changing role of the state.

- **LEGISLATION FOR URBAN MANAGERS: (07 Hours)**

  Significance and Objectives of Legislation for Planners, Constitutional Basis and Provisions, Legal Framework in Town and Country Planning, Preparation and Implementation of Regional Plan/Development plan, T.P. Scheme in Light of The Gujarat Town Planning Act, 1976, Provisions of Land Acquisition Act, Urban Land Ceiling Act and Conservation Act.

- **REGULATIONS: (06 Hours)**

  Financing of infrastructure including exactions, tax policies, funding municipal services. Zoning and land use control regulatory takings, vested rights, permits and project review.

- **ROLES OF POLITICS IN PLANNING: (04 Hours)**

  Politics related to land, shelter, urban infrastructure, resources; Regeneration and redevelopment politics; politics of provision, financing and pricing; decision-making and decision-taking, Politics and emergence of civil society – NGO, CBO and their role in planning, development and management, collective bargaining and collective action.

(Total Lectures: 45 Hours)

3. References

1. URDPFI Guidelines, Ministry of Housing and Urban Dev., Govt. Of India. 2015
2. The Gujarat Town Planning and Urban Development Act, 1976
3. Comprehensive General Development Control Regulations – 2017. Govt. of Gujarat
4. Handbook of Environmental Laws, Vol. I and II, Enviro-media Publication, Karad, Maharashtra.
5. Maharashtra Act No. IV of 1975: The Bombay Meetropolitan Region Development Authority Act, 1974, Govt. of Maharashtra, Law and Judiciary Deptt., published by the Director General, Govt. Printing, Stationery and Publications, Maharashtra State, Bombay 400004

4. CO-PO-PSO Mapping

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	0	0	1	1	1	0
CO2	2	2	2	1	3	1
CO3	3	0	3	2	3	1
CO4	1	0	0	2	1	2
CO5	2	2	1	2	2	2

CORE ELECTIVE – 3

CEUP114 URBAN ECONOMICS AND SOCIOLOGY

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understand the basics of urban economics and finance
CO2	Analyzing the public finance and project development cost
CO3	Predicting the economic growth and developing quality of life
CO4	Comprehending urban sociology and cultural aspects
CO5	Developing Socio-cultural aspects of community

2. Syllabus

- **URBAN ECONOMICS BASICS AND CONCEPTS: (10 Hours)**

  Introduction to the principles of economics. Importance of economics in Urban Development. Concepts of demand, supply, elasticity and consumer markets, revenue, Economies of scale, economic and social costs, production and factor market; price determination, cost-benefit analysis, public sector pricing; Determinants of national income, consumption, investment, inflation, unemployment, capital budgeting, risk and uncertainty, long-term investment planning. National plans appraisal and economic development in relation to urban development.

- **PUBLIC FINANCE: (08 Hours)**

  Introduction to the principles of public finance. Project development cost. land values, Economic base of cities, Industrial and other economic activity's location, Policies and Urban Development.

- **ECONOMIC GROWTH,DEVELOPMENT AND QUALITY OF LIFE: (07 Hours)**

  Human development index, poverty and income distribution, employment and livelihood; balanced versus unbalanced growth, public sector dominance; changing economic policies, implications on land. Relevant case studies.

- **URBAN SOCIOLOGY BASICS AND CONCEPTS: (12 Hours)**

  Socio-cultural profile of society and urban transformation; Tradition and modernity in the context of urban and rural settlements; Issues related to caste, age, sex, gender and marginalized groups; Displacement, resettlement and rehabilitation. Social problems of slums and Urban poor, urban and rural social transformation and their impact on social life, safety, security; Crimes in urban areas and their spatial planning implications, social structure and spatial planning.

- **ROLE OF SOCIO-CULTURAL ASPECTS: (08 Hours)**

  Growth patterns of city and neighborhood communities; Social planning and policy, community participation; Marginalization and inclusive planning, National Policy. Relevant case studies.

(Total Lectures: 45 Hours)

3. References

1. O'sullivan, A. (2019). Urban Economics. New York: McGraw Hill Education.

2. Jones, C. (2021). Urban Economy: Real Estate Economy and Public Policy. London: Tailor & Francis Group.
3. Sondge, T. (2012). Urban Sociology in India. India: ChandralokPrakashan
4. Abrahamson, M. (2013). Urban Sociology: A Global Introduction. UK: Cambridge University Press.
5. Moss L. (2001), 'City and Country: An Interdisciplinary Collection', Wiley Blackwell

4. CO-PO-PSO Mapping

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	1	0	0	2	1	1
CO2	3	2	1	2	2	2
CO3	2	3	2	2	3	2
CO4	2	1	1	3	2	2
CO5	3	2	3	3	3	3

CORE ELECTIVE – 3

CEUP116 REGIONAL PLANNING

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understand the concept of regional planning &development.
CO2	Recognize institutions and organization setup of regional authorities.
CO3	Identify the Requirement of resources for regional development.
CO4	Apply various theories for balanced regional development.
CO5	Prepare proposal on regional plan.

5. Syllabus

- **REGION AND REGIONAL DYNAMICS** **(10 Hours)**

  Region: Definition, Typology, classifications and Delineation of regions.

  Regional Dynamics: Growth of Mega and Metro Regions: Scale, Complexity and its impact on national and international scenario, convergence and divergence.

  Regional Economy, competitiveness among regions, backward and leading regions in development; Special Regions: SEZ, Agro Regions, Ecological regions, etc.

- **REGIONS IN INDIA AND ITS PLANNING** **(10 Hours)**

  Region in Indian Context: Resource Regions, Corridors as regions, National, subnational and State as a region, macro, meso and micro regions in India.

  Role of resources in regional development, utilization of resources and environmental problems Sectorial and regional development and imbalances, multilevel planning, special area development plans. Balanced developed development national and state level planning mechanism.

  Case Studies from India: NCR and Delhi Mega Region, Mumbai Mega Region, Greater Mumbai, Kolkata Metro Region, Chennai Metro Region, and other Metro Regions in India. Regional development planning in other countries. Special region plans.

  Resource Regions in India: Western and Eastern Ghats, North Eastern Region, Coastal Regions, and River Valley Regions; Corridors: Golden Quadrilateral, Delhi-Mumbai, Chennai-Bangalore Industrial Corridor, North-South and East-West Corridor Regions.

- **CORE AND PERIPHERY IN A REGION IN INDIAN CONTEXT** **(08 Hours)**

  Core, Fringe and Periphery in a Region and its planning; Tools and techniques available for planning regions in India; Role of 73rd and 74th Constitution Amendment Acts in regional plan Preparation and implementation. Concept of District Planning.

- **ELEMENTS OF MICRO AND MACRO ECONOMICS** **(08 Hours)**

  Basic Economics: Demand, Supply, Elasticity, Revenue Cost, National Income, Consumption, Investment, Inflation, Capital Budgeting.

Development Economics: Economic Growth and development, Human Development Index, Economic Principles, Policies and strategies in Land use planning.

- **TECHNIQUES AND GROWTH MODELS OF REGIONAL ANALYSIS (09 Hours)**

  Regional Analysis: Introduction to regional analysis, regional linear programming, regional input-output analysis, factor analysis, industrial location theory, spatial diffusion theory, gravity analysis.

  GROWTH MODELS: Concept of Growth pole and growth foci, core-periphery concept, role of settlements in regional development, urbanisation and regional development, input – output models, central place theory Christaller Loseh.

(Total Lectures: 45 Hours)

6. References

1. Sundaram K. "Urban and Regional Planning in India", New Delhi: Vikas Publishers
2. Chaudhuri, Jayasri R. "An Introduction to Development and Regional Planning", Kolkata: Orient Longman Ltd, 2001
3. Jiwan J. "Regional Development and Planning", Rawat Publications, 2021
4. Allen. N. "Regional Development and Planning for the 21st Century: New Priorities, New Philosophies", Routledge
5. Kanan. C. "Regional Planning: Concept Theory and Practice", Concept Publishing Company, 2017

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	1	0	2	1	0
CO2	0	1	0	1	0	0
CO3	2	2	1	3	1	3
CO4	2	1	2	3	2	2
CO5	3	3	3	3	3	3

CORE ELECTIVE – 3

CEUP118 URBAN DESIGN & LANDSCAPE DEVELOPMENT

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understand the components of Urban Design.
CO2	Understand the concept of Landscape Planning in urban context.
CO3	Implement sustainable and balanced urban planning with beauty, convenience and health with the use of dynamic architectural techniques.
CO4	Design using strategies like concept planning, designing, development; zoning by function to balance urban area.
CO5	Develop Revenue generation techniques.

2. Syllabus

- **SCOPE AND OBJECTIVES OF URBAN DESIGN** **(04 Hours)**

  Its relationwith architecture and urban planning, scale of various urban design projects, regional and city level, urban design survey, inventories, techniques/approaches to urban design. Concepts and theories in landscape architecture/city planning urban design in the historical perspective, origin of forms, organization of space, relationship of activity with buildings.

- **BEHAVIORAL ISSUES IN URBAN DESIGN** **(04 Hours)**

  Principals of urban spatial organization, urban scale, urban spaces, urban massing, quality of urban enclosure. Imageability, townscape and elements of urban design (Gordon, Cullen, Kevin Lynch) Urban conservation with historic preservation and integrated approach to conservation, urban renewal, its purpose, economics and planning issues.

- **URBAN DESIGN AT MICRO LEVEL** **(06 Hours)**

  Campus planning, city centres, transportation corridors, residential neighbourhood, water fronts. Urban landscape in relation to topography.

- **DEVELOPMENT CONTROL GUIDELINES** **(06 Hours)**

  Zoning, Historical examples of urban design projects. Evaluation/ feasibility study of urban design projects.

- **OBJECTIVES AND SCOPE OF LANDSCAPE PLANNING** **(06 Hours)**

  Behavioural issues landscape design, principles and aesthetic theory in landscape design, Land from design and elements of geomorphology, hydrology, paedology, drainage in landscape planning. Spatial organization of selected cities, emphasizing landscape assessment.

  Siteand resources inventory Methods, analyses and appraisal, landscape suitability analysis, Plant characteristics and planting design, environmental factors in landscape planning.

- **OUTDOOR RECREATION AND TOURISM** **(02 Hours)**

  Planning and design issues.

- **LANDSCAPE PLANNING** **(08 Hours)**

  Urban and regional level open spaces, residential neighbourhoods, urban roads and regional highways, coastal area landscape planning. Landscape Urbanism, sustainable landscape, streetscape Waterfronts, evolution of different landscape philosophies.

- **OPEN SPACE SYSTEM** **(06 Hours)**

  Concept for opens space and park system in urban area. Open space development in urban design context. Evolution of Public Park as a major component of urban landscape. Open space development in new towns. Park systems, water fronts. Green infrastructure. Urban ecology, urban water sheds.

- **EVALUATION PROCESS IN LANDSCAPE PLANNING** **(03 Hours)**

  Critical appraisal of historical examples of landscape plans. Relevance of Social forestry in urban and regional landscape planning.

(Total Lectures: 45 Hours)

3.References

1. Paul, Spreiregen D., "Urban Design: The Architecture of Town and Cities", New York: McGraw Hill Book Company,2020
2. Shimizu H. and Murayama A., "Clinical Environmental Approaches in Landscape Planning", Urban and Landscape Perspectives, 2014
3. John.F., "Urban Landscape Design",Teneues Media Gmbh& Co, 2008
4. Grazia.C, "Human Smart Cities: Rethinking the Interplay between Design and Planning", Springer, 2018
5. Nigel D. "The Dynamic Landscape: Design, Ecology and Management of Naturalistic Urban Planting", Taylor & Francis

4. CO-PO-PSO_Mapping

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	1	0	1	1	0	0
CO2	1	0	0	2	1	1
CO3	2	1	3	2	3	2
CO4	3	3	3	3	3	3
CO5	3	3	3	2	2	2

CORE ELECTIVE – 3

CEUP120 PLANNING AND DEVELOPMENT OF INFORMAL SECTOR

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understand the urbanization and urban poor
CO2	Reviewing the Policies and acts related to the development of poor
CO3	Predicting the growth of informal and formal sectors and its trends
CO4	Analyzing the role of migration and economic growth
CO5	Developing economies and housing opportunities for the informal sector

2. Syllabus

- **URBANIZATION AND URBAN POVERTY: (08 Hours)**

  Formal and Informal economy challenges and opportunities, Economic linkages, interdependency and Economic flows of formal and informal sector, forward and backward linkages, Role of informal economy and informal sector in overall economic development, Socio-cultural and environment perspectives.

- **HOUSING FOR SLUMS: (12 Hours)**

  Housing policies for the urban poor, Housing demand and assessment, Role of migration, social housing projects and best practices, case studies and examples.

- **REVIEW OF POLICIES, ACTS AND PROGRAMMES: (06 Hours)**

  Review national and international scenario, innovation in the informal sector, survey techniques for socio-economic analysis and spatial analysis, measurement and assessment with projection of informal sector, Plan formulation and integration with spatial plans.

- **PLANNING FOR URBAN VILLAGE: (11 Hours)**

  Character of urban village, Problem and issue identification, Policies and guidelines for development and redevelopment, financial models and Governance structure

- **PLANNING OF POLICIES AND STATERGIES: (08 Hours)**

  Preparation of policies and strategies for informal setting for development, redevelopment, renewal or rejuvenation

(Total Lectures: 45 Hours)

3. References

1. Nurul, A. (2010). The Informal Sector in Asia. VDM Verlag.
2. Wiliams, C. and schneidar F. (2016). Measuring the Global Shadow Economy: The Prevalence of Informal Work and Labour. Edward Elgar Publisher
3. Mukhopadhyay I. (2022) Employment in the Informal Sector in India. Singapore: Springer
4. Barnes T. (2018). Informa Labour in India: Three Cities, Three Journeys. Routledge.
5. Mohsen. A (2021), 'Resilience of Imformal Areas in Megacities- Magnitude, Challenges and Policies: Strategic Environment' Springer Nature Switzerland

4. CO-PO-PSO Mapping

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	0	0	0	2	1	1
CO2	1	1	1	2	3	2
CO3	2	1	2	2	2	2
CO4	2	1	1	3	3	3
CO5	3	2	3	3	3	3

CORE ELECTIVE – 3

CEUP122 URBAN DYNAMICS

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understanding the urbanization trends
CO2	Comprehending the theories of growth
CO3	Analyzing the reasons for development and underdevelopment
CO4	Derive connection between the capital and development
CO5	Practice the application of theories

2. Syllabus

- **URBAN AND URBANIZATION: (10 Hours)**

  Definitions of Urban, urbanization, drivers of urban growth, problems and prospects of urbanization, urbanization in India, systems thinking, system, system dynamics, urban system, urban dynamics, functions of urban system, introduction to system dynamics modelling, modelling urban problems – based on current issues and field studies.

- **THEORIES OF DEVELOPMENT AND UNDERDEVELOPMENT: (15 Hours)**

  Concepts of development and growth, Indicators of development, Ingredients of development - Economic base of cities and regions, Basic concepts of economic resources - Basic concepts in macro-economic and economic analysis - Economics of scale and external economics. Theories of development - Role of cities in regional and national development –Friedman and Myrdal – Top-down and bottom-up approaches and concepts of integrated regional development - classical and neo-classical theories of urban and regional development Theories of under development - Dependency, imperialism – World system approach – hierarchical placements and positioning of regions and spatial forms Dichotomy of North-South, Rich-Poor -Third world urbanization – Metropolitan Dominance and hegemony – patterns of urban and regional development and disparities

- **CAPITAL, CITY AND DEVELOPMENT: (10 Hours)**

  Critical links between capital and cities –feudal, industrial and financial capital -Theoretical Foundations - Historical, Sociological and Spatial Roots -Perspectives on Cities

- **DIFFERENT STATERGIES AND APPLICATION OF THEORIES: (10 Hours)**

  Different strategies and theories for compact cities, shrinking cities, urban sprawl, regional plan formulation for managing dynamics, application of various tools and techniques

(Total Lectures: 45 Hours)

3. References

1. Forrester J. (1969). Urban Dynamics. Pegasus Communications.
2. Siddharatha K. and Mukharjee S. (2019). Cities Urbanization and Urban Systems. Delhi: Kitab Mahal
3. Bertuglia C. (2011). Urban Dynamics: Designing an Integrated Model. Routledge
4. Shaw, S. (2021). Urban Human Dynamics. Springer Journal

5. Gregory. F (2022), ‘Urbanormativity: Reality, Representation, and Everyday Life’ Lexington

4. CO-PO-PSO Mapping

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	0	0	1	2	1	0
CO2	0	0	1	1	2	0
CO3	2	1	2	2	2	1
CO4	3	2	1	2	3	3
CO5	3	2	3	2	3	2

INSTITUTE ELECTIVE – 1

CECS230 AI/ML BASED APPLICATIONS IN CIVIL ENGINEERING

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Comprehend the basic principles of artificial intelligence (AI) and machine learning (ML) algorithms.
CO2	Understanding Data collection & management tools & techniques for AI/ML application to Civil Engineering.
CO3	Derive the need and benefits of using AI/ML algorithms for developing applications in Civil Engineering using big-data analysis.
CO4	Solve the real-life problems in Civil Engineering using real-time data collection and big-data analysis involving AI/ML tools.
CO5	Evaluate the performance of different AI/ML algorithms towards a given application in civil engineering.

2. Syllabus

- **INTRODUCTION TO MACHINE LEARNING** **(8 hours)**

Machine Learning Basics: Data Collection, Data Management, Big data, taxonomy of machine learning algorithms, **Supervised Learning:** Classification – Bayesian Classifier, K-nearest Neighbours, Regression- Linear Regression, Multivariate Regression, Logistic regression. Support Vector Machine (SVM) Algorithm. **Unsupervised Learning:** Clustering- K-means clustering algorithm and Hierarchical clustering algorithm. **Reinforcement Learning:** Q-Learning algorithm.

- **DATA COLLECTION APPARATUSES** **(8 hours)**

Type of data sources, Types of data, Types of sensors, Edge-devices, Introduction to microcontrollers, data communication protocols, Cloud storage and cloud computing, Local server setup, Cloud server setup, Introduction to Python, Introduction to Django server, Database setup.

- **APPLICATIONS IN CIVIL ENGINEERING** **(15 hours)**

Intelligent Transportation systems, smart mobility, shared mobility, Mobility as a Service (MaaS), Real-time data monitoring, Structural health monitoring, Fire resistance evaluation of structures, automation in water resource management, Water quality monitoring, water distribution system monitoring, air and noise pollution monitoring, Rainfall-runoff modelling, Climate change monitoring, Soil liquefaction, Forecasting foundation related parameters, Building occupancy modelling, Building information modelling, Energy demand prediction, Predictive maintenance of equipment, roads and buildings

- **APPLICATION PART I: DATA COLLECTION AND MANAGEMENT** **(7 hours)**

Image processing for real time applications in Civil Engineering**,** Description of available database across specialisations**,** Selection of sensors and microcontroller, Integration of sensors with Edge-device, Programming of Edge-devices, Programming of server in Django framework, Collection of sensor data and storing to Database, Cloud computing

- **APPLICATION PART II: BIG DATA ANALYSIS** **(7 hours)**

Selecting the appropriate ML algorithm for analysis, Data Processing, Analysing the importance of each variable in decision making, and Analysis of processed data.

(Total Lecture : 45 Hours)

3. References:

1. Manaranjan Pradhan, U Dinesh Kumar "Machine Learning using Python", Wiley.
2. Deka P C,A "Primer on Machine Learning Applications in Civil Engineering" Taylor & Francis.
3. Charles R. Farrar, Structural Health Monitoring: A Machine Learning Perspective, Keith Worden, Wiley.
4. John Soldatos "Building Blocks for IoT Analytics", Athens Information Technology, Greece, River Publishers.
5. Samuli Natri."Django - The Easy Way" (2nd Edition),
6. Adrian Holovaty, Jacob Kaplan-Moss "The Django Book (Release 2.0)" 2013.
7. Benjamin J. R., Cornell C. A., "Probability Statistics and Decision for Civil Engineers", McGraw-Hill, 1970.
8. Simon P. Washington, Matthew G. Karlaftis, Fred, Mannering L., "Statistical and Econometric Methods for Transportation Data Analysis", CRC Press, Second Edition, 2010.
9. Richard A. Johnson, Dean W. Wichern, "Applied Multivariate Statistical Analysis", Prentice Hall, 1992.

4. Other Material:

1. Arduino-ESP32 (Release 2.0.2), Espressif, 2022.

5. CO-PO-PSO Mapping

Course Objective	Program Specific Outcome			Program outcomes		
	PO1	PO2	PO3	PSO1	PSO2	PSO3
1	3	3	3	3	3	3
2	3	2	3	3	2	2
3	3	3	3	3	3	3
4	3	3	3	3	2	3
5	3	2	3	3	3	3

Note: 1: Slightly 2: Moderately 3: Substantially

INSTITUTE ELECTIVE – 1

CEUP172 Smart Cities Planning and Management

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain concept and global practices.
CO2	Study performance benchmarks, practice codes and national mission.
CO3	Design Smart Cities and draft relevant project management schemes.
CO4	Explain phases of Implementation and monitoring.
CO5	Explain phases of Finance and Governance.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**
  Concept and practice of Smart Cities across the world, Purpose and importance of Smart Cities, Role of different stake-holders.

- **FRAMEWORK** **(10 Hours)**
  Human framework, Institutional framework, Energy framework, Data Management framework and technology framework, Present practice of road map for planning and benchmarking their performance for Indian context, accelerate impact, scaling up and across

- **PLANNING AND MANAGEMENT** **(16 Hours)**
  Planning and management for area-based development, PAN city solutions and retrofitting of existing area, greenfield development, integrated planning approach

- **SMART SOLUTIONS** **(08 Hours)**
  ICT in Smart City, Smart monitoring, Technology, Challenges, solutions and work around, replication and upscaling, Smart Infrastructure for building, mobility, energy, water and solid waste

- **FINANCE AND GOVERNANCE** **(04 Hours)**
  E-finance, E-governance, balancing top-down and bottom-up approach

(Total Lectures: 42 hours)

3. Books Recommended

1. J Borsboom-van Beurden, Smart City Guidance Package for Integrated Planning and Management, NTNU, 2017.
2. Ministry of Urban Development Government of India, Smart Cities: Mission Statement & Guidelines, 2015.
3. T M V Kumar, E-Democracy for Smart Cities, Springer Nature, Singapore, 2019.
4. T M V Kumar, Smart Metropolitan Regional Development: Economic and Spatial Design Strategies, Springer Nature, Singapore, 2019.

4. Mapping of COs and POs

	PO1	PO2	PO3
CO1	1	2	1
CO2	2	2	1
CO3	3	3	3
CO4	2	2	2
CO5	2	2	2

0-Not related 1-Low 2-Moderate 3-High

5. Mapping of COs and PSOs

	PSO1	PSO2	PSO3
CO1	1	0	1
CO2	2	1	1
CO3	3	3	3
CO4	1	2	2
CO5	1	2	2

0-Not related 1-Low 2-Moderate 3-High

SEMESTER – III

CEUP205 DESIGN PORTFOLIO

L	T	P	C
0	0	4	2

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Understand the process of evaluation and appraisal of Development Plans.
CO2	Identify land Use Plan and growth potential of the city.
CO3	Develop capabilities to assess the urban policy framework of the city
CO4	Prepare or Modify development Plan with reference to the Act and guidelines along with its report.
CO5	Formulate financial mechanism for the urban infrastructure projects.

Design portfolio in planning addresses evaluation and appraisal of Development Plan of one Major city/Mega City /Metropolitan Areas of India or abroad. Study shall cover assessment of objectives, carry out surveys, assess growth potentials, preparation of one land use plan of the development plan adopted, and is evaluated for the policy, planning design, implementation procedure and development controls regarding the land use. Dos and Don’ts in professional Bodies

2. Design Portfolio Work:

a. The students shall carry out preliminary assessment of the City through literature survey, data available on websites and other secondary sources.
b. Prepare detailed questionnaire for data collection during the field visits.
c. Visit one City carry out surveys and data collection activities and thoroughly study the development plans, policies, implementation models, schemes etc.
d. Hold discussions with Government Authorities / Stakeholders
e. Carry out in depth appraisal of reports, & analysis of data collected and prepares appraisal report.

The studies need to be carried out mainly through primary data collection. A field visit to any Major or Mega town/city in India / Abroad has to be made. The students are required to submit typed report (A-4, size papers, spiral bound, 2 copies) along with studio exhibits (imperial/ A1size drawing sheet) for the Design Portfolio Work. The work shall be carried by the team and to be presented before a panel of examiners including one external examiner.

3. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	0	0	1	1	1	1
CO2	1	0	1	2	2	2
CO3	3	1	2	2	3	3
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3

CEUP 207 SUMMER TRAINING

L	T	P	C
0	0	0	0

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1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Explore different possibility where urban planners can apply their knowledge.
CO2	Gain exposure of working in field with experts and team.
CO3	Solve practical problems with urban planning approaches.
CO4	Promote academic & industry networking.
CO5	Develop technical as well as professional skills.

Summer Training is the Non-credit/Audit Course for the students to take professional experience Six to eight weeks' summer training in Urban planning is to be undertaken at National/State/Local Government / Private Agencies after the Second Semester Examination prior to opening of Third Semester and project report on the same is to be prepared & submitted duly certified by the Project Organization.

2. Summer Internship Work

a. The student shall submit weekly diary to PG-In-Charge stating the work undertaken.
b. Prepare summer internship report comprising of salient features of the assignment(s) handled, organizational setup and learning of issues & challenges.
c. Student has to produce a copy of attendance register (during the internship) duly signed by the Competent authority.

The students are required to submit typed report (A-4, size papers, spiral bound, 2 copies) on the summer internship work and present it before a panel on the scheduled date.

3. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	0	1	1	2	1
CO2	0	0	3	1	1	3
CO3	3	3	3	3	3	3
CO4	0	2	1	3	0	2
CO5	2	3	3	3	1	3

CEUP295 DISSERTATION PRELIMINARY

L	T	P	C
0	0	28	14

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1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Explore current or upcoming issues and research areas in the relevant field of Urban Planning.
CO2	Identify the process & importance of Literature Survey in identifying research areas.
CO3	Review the literature to find out the need of the research areas and setup of objectives.
CO4	Develop the Methodology of research and prepare work schedule.
CO5	Select the sample size, formulate questionnaires and choose models for analysis.

Dissertation Preliminaries should clearly identify the goals/objectives and scope of the dissertation work taken up by the student. Details of data identification and field surveys should be clearly highlighted. The study approach and literature review should be discussed. A typed report shall be submitted at the end of the semester, which shall be assessed by the P. G. Section.

2. Dissertation Preliminaries Work

a. The student shall carry out literature survey preferably of last five years of good journals/ reports etc.
b. The topic of Dissertation shall be selected by the student in consultation with Research Guide
c. The student shall prepare the focus area of dissertation and finalise the study area / objective / scope of study and Methodology
d. The sample size of data collection and questionnaire shall be prepared & approved.
e. The student shall present introduction, literature review and study area profile during the continuous assessment
f. Students are expected to carry out pilot survey (10-25 Nos) preferably during the semester break.

The students are required to submit typed report (A-4, size papers, spiral bound, 2 copies) for the Dissertation Preliminaries Work. The work shall be presented before the panel of Research Guide & Internal Examiner.

3. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	0	1	2	3	2
CO2	0	1	2	1	2	0
CO3	2	3	2	2	3	1
CO4	3	3	3	2	2	0
CO5	3	3	3	3	3	2

SEMESTER – IV

CEUP296 DISSERTATION

L	T	P	C
0	0	40	20

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Generate scope for original and independent study/research
CO2	Conceive ideas through the conduct of the research.
CO3	Asses the previous research and existing literature and data
CO4	Gain the ability & confidence to undertake field studies, data collection, analysis and presentation
CO5	Prepare proposal on the research area

2. Syllabus

Each student is to carry out the dissertation work on the topic in which the Dissertation Preliminary has been done in the third semester.

The main objective of dissertation work is to provide scope for original and independent study/research, to develop a theme and to demonstrate ability of using analytical approach or investigate independently. The theme or topic of dissertation should be within the framework of P.G. Programme.

Thesis is prepared by each student under the supervision of the faculty advisor and to be submitted in six typed bound sets as per the specified time. The assessment of the dissertation will be carried out during the semester through continuous assessment on progress made and the final viva voce examination after the submission of thesis. The first assessments will be by the P.G. Section and for the final assessment by the Institute.

3. DISSERTATION WORK:

1) The student shall undertake data collection and analysis and present
2) Finalize the model adopted for research work
3) Prepare planning proposals with different alternatives
4) During continuous assessment the student shall present the research work
5) Publish research papers on the research area as per Institute Guidelines

The students are required to submit typed Thesis (A-4, size papers, spiral bound, 3copies and 2 No's of Posters) in the initial stage and after Institute Assessment submit 6 Nos of bound copies of Thesis as per Institute guidelines.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	0	1	2	3	2
CO2	0	1	2	1	2	0
CO3	2	3	2	2	3	1
CO4	3	3	3	2	2	0
CO5	3	3	3	3	3	2

M. Tech.

Computer Science and Engineering

(CSE)

Curriculum and Syllabus

Department of Computer Science and Engineering

M.Tech. Computer Science and Engineering

Sr. No.	Subject	Code	Scheme L-T-P	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
				Th. Marks	T Marks	P Marks		
	First Semester							
1	Mathematical Foundations of Computer Science (Core – 1)	CSCS101	3-1-0	100	25	0	4	70
2	Design and Analysis of Algorithms (Core – 2)	CSCS103	3-0-2	100	0	50	4	85
3	Machine Learning (Core – 3)	CSCS105	3-0-2	100	0	50	4	85
4	Core Elective -1	CSCS1XX	3-1-0 / 3-0-2	100	0 / 25	0 / 50	4	70 / 85
5	Core Elective - 2	CSCS1XX	3-0-2	100	0	50	4	85
						Total	**20**	**395 - 410**
6	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	CSCSV91 CSCSP93	0-0-10				5	200 (20 x 10)
	Second Semester							
1	Wireless Network and Mobile Computing (Core – 4)	CSCS102	3-0-2	100	0	50	4	85
2	Distributed System (Core – 5)	CSCS104	3-0-2	100	0	50	4	85
3	Elective - 3	CSCS1XX	3-1-0 / 3-0-2	100	0 / 25	0 / 50	4	70 / 85
4	Elective - 4	CSCS1XX	3-0-2	100	0	50	4	85
5	Institute Elective*	CSCS1XX	3-0-0 / 3-0-2 / 3-1-0	100	0 / 25	0 / 50	3 / 4	55 / 70 / 85
6	Mini Project	CSCS1XX	0-0-4	-	-	100	2	70
						Total	**21 – 22**	**450 - 495**
7	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	CSCSV92 CSCSP94	0-0-10				5	200 (20 x 10)
	Third Semester							
1	MOOC course – I*	Φ	-	-	-	-	3 / 4	70 / 80
2	MOOC course – II*	Φ	-	-	-	-	3 / 4	70 / 80
3	Dissertation Preliminaries	CSCS295	-	-	-	350$	14	560
						Total	**20 - 22**	**700 - 720**
	Fourth Semester							
1	Dissertation	CSCS296	-	-	-	600$	20	800
						Total	**20**	**800**

L: Lecture; T: Tutorial; P: Practical; Th: Theory

*to be offered to the PG students of other department and other PG Programs with the department.

Subject Code: Core, Electives, Dissertation Preliminary and Dissertation: **$$##nXX;** Vocational Training: **$$##VXX;** Professional Experience: **$$##PXX; $$:** Department Name; **##**: M.Tech Course Identity; **n**: Year; **XX**: Core (01 to 10), Elective (11 to 70), Institute Elective (71 to 90), Vocational Training (91 to 92), Professional Experience (93 to 94), Dissertation Preliminary (95), Dissertation (96), XX last digit odd number (for odd semester); XX last digit even number (for even semester)

Calculation of Notional Hours for the subject containing Theory, Tutorial and Practical Example: 3-1-2: 3*15+1*15+2*15+10 (Exam)= 100

$ **Internal**: 40% and **External**: 60%, *Swayam/NPTEL, ϕ As per 66th IAAC, Dated 20th March, 2024, Resolution No. 66.34 and 61st Senate resolution No. 4, 25th April, 2024.

Code	Elective Subjects	Scheme
	Core Elective 1 and 2	
CSCS111	Computer Vision and Image Processing	3-0-2
CSCS113	Advanced Database Management System	3-0-2
CSCS115	High Performance Computing	3-0-2
CSCS117	Foundation of Data Science	3-0-2
CSCS119	Embedded Systems Design	3-0-2
CSCS121	Speech and Audio Processing	3-0-2
CSCS123	Cloud Computing and Big Data Analytics	3-0-2
CSCS125	Principles of Information Security and Privacy	3-0-2
CSCS127	Research Methodology in CSE	3-1-0
CSCS129	Probabilistic Graphical Models	3-1-0
CSCS131	Artificial Intelligence	3-0-2
CSCS133	Cyber Physical Systems	3-0-2
CSCS135	Digital Forensics	3-0-2
CSCS137	Machine Learning for Security	3-0-2
CSCS139	Identity and Access Management	3-0-2
CSCS141	Software Security	3-0-2
CSCS143	Security and Privacy in Resource Constrained Environments	3-0-2
CSCS145	Blockchain Fundamentals and Use cases	3-0-2
CSCS147	Network Security	3-0-2
CSCS149	Modern Cryptography	3-1-0
CSCS151	Information Retrieval	3-0-2
CSCS153	Big data analytics and large-scale computing	3-0-2
	Core Elective 3 and 4	
CSCS112	ANN and Deep Learning	3-0-2
CSCS114	Introduction to Formal Specification and Verification	3-0-2
CSCS116	Natural Language Processing	3-0-2
CSCS118	Reinforcement Learning	3-0-2
CSCS120	Data Mining and Data Warehousing	3-0-2
CSCS122	Data Science for Software Engineering	3-0-2
CSCS124	Security and Privacy in Social Networks	3-0-2
CSCS126	Foundations of Privacy Engineering	3-1-0
CSCS128	Malware Analysis and Mitigation	3-0-2
CSCS130	Secure Software Engineering	3-0-2
CSCS132	Mobile Security and Penetration Testing	3-0-2
CSCS134	Bitcoin and Cryptocurrency Technologies	3-0-2

CSCS136	Security Protocols	3-0-2
CSCS138	Hardware Security	3-0-2
	Institute Elective	
CSCS172	Social Networks	3-0-0
CSCS174	Cyber Laws	3-0-0
CSCS176	Ethical Hacking and Penetration Testing	3-0-2

M. Tech. I CSE Semester – I	L	T	P	C
CSCS101: MATHEMATICAL FOUNDATIONS OF COMPUTER SCIENCE (CORE-1)	**3**	**1**	**0**	**4**

Course Objective	
1	To learn the fundamental concepts of set theory, functions, probability.
2	To study the graph theory, its applications and combinatorics problem solving arising in many applications.
3	To learn different statistical inference procedures, probability distributions and random processes.
4	To enable the student for applying the knowledge of linear algebra and statistical analysis in different field of computer science and engineering.
5	To design an efficient solution using linear algebra and statistical methods for real time problems.

INTRODUCTION	**(04 Hours)**
Set theory, Logic and Proofs, Conditional Propositions, Logical Equivalence, Predicates, Quantifiers, Combinatorics	
FUNCTIONS AND RELATIONS	**(04 Hours)**
Types of functions, Recursive functions, Computable and non-computable functions, Representations of relations, Composition and properties of relations	
GRAPH AND AUTOMATA	**(09 Hours)**
Different types of graphs, Trees, Basic Concepts Isomorphism and Sub graphs, Multi graphs and Euler circuits, Hamiltonian graphs, Chromatic Numbers, Graph and Tree processing algorithms, Different types of Automata, Formal Languages, Regular expressions, Context free grammars	
PROBABILITY AND RANDOM VARIABLES	**(09 Hours)**
Overview of Sample points and Sample spaces, Events, Bayes theorem, Probability axioms, Joint and conditional probability, Random variables, Discrete and continuous random variables, Random vectors, Transformation of continuous random variables and vectors by deterministic functions, Density functions of transformed continuous random variables and vectors, Multivariate random variables, Moments and moment generating functions, Functions of random variables.	
RANDOM PROCESSES	**(09 Hours)**
Random variable vs. Random process, Bernoulli random process, Binomial process, Statistical averages, Ensemble and time averages, Weak and strict sense stationarity of a random process, Ergodicity, Autocorrelation and Auto covariance functions of random processes and its relation to spectra, Poisson process, Gaussian process, Martingale model and Markov Chains.	
ESTIMATION AND STATISTICAL ANALYSIS	**(10 Hours)**
Estimation of parameters from data, Maximum likelihood estimation, Maximum a posterior estimation, Consistency and Efficiency of Estimators, Stochastic State Estimation and MSE of an Estimator, Estimation of Gaussian Random Vectors, Linear minimum mean square error estimation, Hypothesis testing, Significance level, Types of errors: Type-I and Type-II, Significance Test, Chi-Squared, Student-t test, Normality test, Cramer-Rao bound on estimators, Chebyshev inequality, KullbackLeibler divergence, Applications.	
Tutorial Assignments Will Be Based on the Coverage of Above topics.	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)

BOOKS RECOMMENDED

1. Kenneth H. Rosen, "Discrete Mathematics and Its Applications", McGraw-Hill, 8th Edition, 2021.
2. Gersting J.L., "Mathematical Structure for Computer Science", W.H. Freeman and Co., 3rd Edition, 1993.
3. A. Papoulis and S. U. Pillai, "Probability, Random Variables and Stochastic Processes", 4th Edition, 2017.
4. W B Davenport, "Probability and Random Processes - an introduction for application scientists and engineers", McGraw Hill, 1970.
5. S. M. Ross, Introduction to Probability Models", Academic Press, 12th Edition, 2019.

Course Outcomes **At the end of the course, students will**	
CO1	have a knowledge of the basic concepts and problems of set theory, predicates and logic
CO2	be able to use functions, graphs, trees, automata and formal languages for problem solving
CO3	be able to analyze/interpret quantitative data verbally, graphically, symbolically and numerically.
CO4	be able to evaluate and compare the results using different linear algebraic and statistical techniques.
CO5	be able to use linear algebra for optimization and integrate statistical models for solving real life applications.

M. Tech. I (CSE) Semester – I	**L**	**T**	**P**	**C**
CSCS103: DESIGN AND ANALYSIS OF ALGORITHMS (CORE-2)	**3**	**0**	**2**	**4**

Course Objective	
1	To understand paradigms and approaches used to analyze and design algorithms and to appreciate the impact of algorithm design in practice.
2	To analyze the worst-case time complexity of an algorithm, asymptotic complexities of different algorithms.
3	To design and prove the correctness of the algorithms using appropriate design technique to solve a given real-world computational problem.
4	To analyze and prove the computational intractability of the algorithms of the hard computational problems.
5	To design sub-optimal solutions for the intractable computational problems using alternate design approaches.

INTRODUCTION	**(02 Hours)**
Review of Basis Concepts in Algorithms, Abstract Machines, Analysis Techniques: Mathematical, Empirical and Asymptotic analysis, Review of the Notations in Asymptotic Analysis, Recurrence Relations and Solving Recurrences, Proof Techniques, Illustrations.	
DIVIDE AND CONQUER APPROACH	**(06 Hours)**
Review of Sorting & Order Statistics, Various Comparison based Sorts Analysis, Medians and Order Statistics, The Union-Find Problem, Counting Inversions, Finding the Closest Pair of Points; Lower Bound on Sorting and Non-comparison based Sorts.	
SEARCHING AN DSET MANIPULATION	**(02 Hours)**
Searching in Static Table Binary Search, Path Lengths in Binary Trees and Applications; Optimality of Binary Search in Worst Case and Average Case; Binary Search Trees, Construction of Optimal Weighted Binary Search Trees; Searching in Dynamic Table, Randomly Grown Binary Search Trees, AVL and (a, b) Trees.	
HASHING	**(02 Hours)**
Basic Ingredients, Analysis of Hashing with Chaining and with Open Addressing; Union-Find Problem: Tree Representation of a Set, Weighted Union and Path Compression-Analysis and Applications.	
GREEDY DESIGN TECHNIQUE	**(06 Hours)**
Review of Basic Greedy Control Abstraction, Activity Selection Problem & Variants, Huffman Coding, Horn Formulas; The Knapsack Problem, Clustering; Minimum-Cost Arborescence; Multi-phase Greedy Algorithms, Graph Algorithms; Graph problems: Graph Searching, BFS, DFS, Shortest First Search Minimum Spanning Trees, Single Source Shortest Paths, Maximum Bipartite Cover Problem, Applications, Topological Sort; Connected and Bi-connected Components; Johnson's Implementation of Prim's algorithm using Priority Queue Data Structures.	
DYNAMIC PROGRAMMING	**(08 Hours)**
The Coin Changing Problem, The Longest Common Subsequence, The 0/1 Knapsack Problem; Memoization; Dynamic Programming over Intervals, Shortest Paths and Distance Vector Protocols; Constructing Optimal Binary Search Trees; Algebraic Problems: Evaluation of Polynomials With or Without Preprocessing; Winograd's and Strassen's Matrix Multiplication Algorithms and Applications to Related Problems, FFT, Simple Lower Bound Results.	

STRING PROCESSING	**(02 Hours)**
String Searching and Pattern Matching, Knuth-Morris-Pratt Algorithm and its Analysis; Probabilistic Algorithms, Motivation.	
BACKTRACKING AND BRANCH & BOUND	**(04 Hours)**
Backtracking, General Method, 8-Queens' Problem, Sum of Subsets Problem, Graph Coloring, Hamiltonian Cycles; Branch and Bound to Solve Combinatorial Optimization Problems.	
NP Theory	**(08 Hours)**
Polynomial Time Verification, NP-Completeness & the Search Problems, The Reductions, Dealing with NP-Completeness, Local Search Heuristics, Space Complexity; Selected Topics - Algorithms for String Matching, Amortized Analysis, Bloom Filters & Their Applications.	
PROBABILISTIC ALGORITHMS	**(02 Hours)**
Indicator Random Variables, Four Main Design Categories, Randomization of Deterministic Algorithms, Monte Carlo Algorithms, Las Vegas Algorithms, Numerical Probabilistic Algorithms & Various Candidate Applications Therein.	
APPROXIMATION ALGORITHMS	**(03 Hours)**
Introduction and Motivation for Approximation Algorithms, Greedy and Combinatorial Methods; Scheduling: Multiprocessor Scheduling.	
Practical Assignments will be based on the coverage of above topics.	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

List of Practical (Problem Statements will be changed every year and will be notified on Website.)	
1.	Designing algorithms for trivial computational problems and doing their empirical timing analysis.
2.	Designing algorithms using divide and conquer technique and doing their empirical timing analysis.
3.	Designing algorithms using greedy technique and doing their empirical timing analysis.
4.	Designing algorithms using dynamic programming and doing their empirical timing analysis.
5.	Backtracking & branch bound approach to design algorithms.
6.	Designing Approximation algorithms to solve the hard computational problems.

BOOKS RECOMMENDED

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, "Introduction to Algorithms", The MIT Press.
2. Donald E. Knuth, "The Art of Computer Programming, Vol. 1, Vol. 2 and Vol. 3", Narosa/Addison Wesley, New Delhi/London.
3. Sara Baase, Allen V. Gelder, "Computer Algorithms", Pearson Education.
4. Ellis Horowitz, SartajSahni, "Data Structures, Algorithms and Applications in C++", Universities Press/Orient Longman.
5. J. Kleinberg, E. Tardos, "Algorithm Design", Pearson Education.

ADDITIONAL BOOKS RECOMMENDED

1. K. Mehlhom, "Data Structures and Algorithms, Vol. 1 and Vol. 2", Springer-Verlag, Berlin.
2. A. Borodin and I. Munro, "The Computational Complexity of Algebraic and Numeric Problems", American Elsevier, New York.
3. Winograd, "The Arithmetic Complexity of Computation", SIAM, New York.

Course Outcomes **At the end of the course, students will**	
CO1	have knowledge about the application of mathematical formula/technique to solve the computational problem.
CO2	be able to understand, identify and apply the most appropriate algorithm design technique required to solve a given problem.
CO3	be able to analyze and compare the asymptotic time and space complexities of algorithms.
CO4	be able to write rigorous correctness proofs or implementation for algorithms.
CO5	be able to design and give the solution using innovate/synthesize algorithms to solve the computational problems.

M. Tech. - I (CSE) Semester – I	L	T	P	C
CSCS105: MACHINE LEARNING (CORE-3)	**3**	**0**	**2**	**4**

Course Objective	
1	To understand the basic concepts, state-of-the art techniques of machine learning, statistical analysis and discriminant functions
2	To apply different concepts for the machine learning problems
3	To apply and analyze different supervised and unsupervised learning approaches as per the suitability of the problem
4	To understand and evaluate machine learning methods to use them
5	To design solution of problem using different machine learning approaches

INTRODUCTION	**(04 Hours)**
Pattern Representation, Concept of Pattern Recognition, Basics of Probability, Bayes' Decision Theory, Maximum-Likelihood and Bayesian Parameter Estimation, Error Probabilities, Learning of Patterns, Modeling, Regression, Discriminant Functions, Linear Discriminant Functions, Decision surface, Learning Theory, Fisher Discriminant Analysis.	
LINEAR ALGEBRA FOR ML	**(06 Hours)**
SUPERVISED LEARNING ALGORITHMS	**(07 Hours)**
Gradient Descent, Linear Regression, Support Vector Machines, K-Nearest Neighbor, Naïve Bayes, Bayesian Networks, Classification, Decision Trees, ML and MAP Estimates, Overfitting, Regularization, Bayes Classification, Nearest Neighbor Classification, Cross Validation and Attribute Selection, Bayesian Decision Theory, Losses and Risks, Bayesian Networks, Parametric Methods: Gaussian Parameter Estimation, Maximum Likelihood Estimation, Bias and Variance, Bayes' Estimator, Bayesian Estimation, Parametric Classification, Regression, Naive Bayes, Hidden Markov Models, Support Vector Machines, Decision Trees.	
NEURAL NETWORKS AND LEARNING ALGORITHMS	**(06 Hours)**
Artificial Neural Networks, Perceptron, Multilayer Networks, Back Propagation, Deep Neural Networks, Convolutional Neural Networks, Recurrent Neural Networks; Linear Discrimination, Multilayer Perceptrons: Multilayer Perceptrons, Backpropagation Algorithm, Nonlinear Regression, Convergence, Overtraining, Dimensionality Reduction, Gradient Descent, Recurrent Networks, Cross-Validation and Resampling Methods, Bootstrapping.	
UNSUPERVISED LEARNING ALGORITHMS	**(06 Hours)**
Kernel methods, Basic kernels, Types of Kernel, Properties of kernels, Pattern analysis using Eigen decomposition, Principal Component Analysis, Hidden Markov Models, Markov Decision Processes, Nonparametric techniques for density estimation, Parzen-window method.	
MISCELLANEOUS TOPICS	**(06 Hours)**
Dimensionality Measuring Error, Interval Estimation, Hypothesis Testing, Reduction, Feature Selection, Principal Component Analysis, Pattern Analysis using Eigen Decomposition, Principal Component Analysis, Parzen-windows Method, Model Selection and Theory of Generalization, In-sample and Out-of-sample Error, Vapnik-Chervonenkis (VC) Dimension, VC Inequality, VC Analysis.	
APPLICATIONS	**(10 Hours)**
Signal Processing, Image Processing, Biometric Recognition, Face and Speech Recognition, Information	

Retrieval, Natural Language Processing.	
Practical and mini-projects will be based on the coverage of the above topics.	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

List of Practical (Problem Statements will be changed every year and will be notified on Website.)	
1.	Implement classification and regression techniques
2.	Implement clustering and statistical modeling methods
3.	Implement various dimensionality reduction techniques
4.	Implement neural networks and non-parametric techniques
5.	Implement mini-project based on machine learning approaches

BOOKS RECOMMENDED

1. Richard O. Duda, Peter E. Hart, David G. Stork, "Pattern Classification", 2nd Edition, Wiley, 2001.
2. Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.
3. Geoff Dougherty, "Pattern recognition and classification an Introduction", Springer, 2013.
4. Richard O. Duda and Peter E. Hart, "Pattern Classification and Scene Analysis", John Wiley & Sons, 1973.
5. John Shae Taylor and NelloCristianini, "Kernel methods for pattern analysis" Cambridge university press, 2004.

ADDITIONAL BOOKS RECOMMENDED

1. Ranjjan Shinghal, "Pattern Recognition techniques and application", Oxford university press, 2006.
2. Theodoridis and K.Koutroumbas, "Pattern Recognition", 4th Edition, Academic Press, 2009.

Course Outcomes **At the end of course, students will**	
CO1	have knowledge of pattern recognition, regression, classification, clustering algorithms and statistics.
CO2	be able to apply different feature extraction, classification, regression, neural network algorithms and modeling.
CO3	be able to analyze the data patterns and modeling for applying the learning algorithms and non-parametric approaches.
CO4	be able to evaluate the performance of an algorithm and comparison of different learning techniques.
CO5	be able to design solution for real life problems like biometric recognition, natural language processing and its related applications using various tools and techniques of machine learning.

M.Tech-II(CSE) Semester – II	**L**	**T**	**P**	**C**
CSCS102: WIRELESS NETWORK AND MOBILE COMPUTING (CORE-4)	**3**	**0**	**2**	**4**

Course Objective	
1	To learn fundamental concepts in the area of mobile computing and overview of wireless communication networks area and its applications.
2	To understand various terminology, principles, devices, protocols, algorithms and different methodologies used in wireless communication networks.
3	To learn various wireless channel access schemes like multiple division techniques, modulations scheme, topology of mobile communication systems, cellular and adhoc network
4	To learn various issues and challenges of computing in wireless network, and different computing models and algorithms for ubiquitous computing.
5	To develop the design skills for protocols and mobile applications for different applications which are robust and efficient for operating in wireless environment.

INTRODUCTION	**(06 Hours)**
Wired Network vs. Wireless Network, Overview of Wireless Applications, Wireless Transmission: Path loss, Multi-path propagation, Doppler shift, Fading, Time Division Multiplexing, Frequency Division Multiplexing, Spread Spectrum Technique, Direct sequence spread spectrum, Frequency hopping spread spectrum, CDMA - code division multiple access, OFDM - Orthogonal Frequency Division Multiple Access, Satellite Communication, Statistical Modeling of multipath fading channel, Frequency selective and non-selective fading channels, Flat fading channels, Path-loss, Propagation Model, Shadowing, Rayleigh Fading, Equalization, Channel Modeling and Estimation, Blind Channel Estimation, AWGN Channel.	
CELLULAR SYSTEM	**(12 Hours)**
Cellular Network Organization, Cellular System Evolution, Cellular Fundamentals: Capacity, Topology, Operation of Cellular Systems, Cellular geometry, Frequency reuse, Cell spitting, Sectoring, Handoff, Power control, Case study: Global System for Mobile communication (GSM) Network, General Packet Radio Service (GPRS), Code Division Multiple Access (CDMA 2000), Cordless System, Wireless Local Loop, Mobility Management-Location Management, HLR-VLR scheme, Hierarchical scheme, Predictive location management schemes, Types of interference, Estimation of adjacent channel interference and co channel interference, Trunk efficiency, Grade of service, Blocking probabilities, Propagation models, Frequency management and channel assignment. Packet delivery and handover management, Location management, Tunnelling and encapsulation, Route optimization.	
AD HOC WIRELESS NETWORK	**(09 Hours)**
Cellular vs. Ad Hoc, Applications, Issues, MAC protocols, Routing Protocols, Transport Layer Protocol, Multicasting protocols, Security protocols, Key management, Issues and Challenges in Security provisioning, Security attacks, Secured routing, Standards: IEEE 802.11, Wi-Fi, Wireless Broadband-Wi-MAX, Bluetooth, IEEE 802.15, Security in Wireless Network, Hyper LAN.	
MULTI INPUT MULTI OUTPUT	**(09 Hours)**
Single user modulation techniques, Multiple access techniques, Matched filter, RAKE receiver, Equalization, Multi user detection, Blind multi user detection, Bayesian multiuser detection in Gaussian noise, Multi input and Multi Output Communication, MIMO Channel Estimation, MIMO Channel Capacity, Transmitter Diversity, Receiver Diversity.	
MOBILE COMPUTING	**(09 Hours)**

Mobile Computing, Issues: Resource Management, Interference, Bandwidth, Frequency reuse, Mobile Data Transaction Models, Data handling in Mobile computing, Client server computing, Data recovery and query processing, Mobile operating system, Mobile Ad-hoc and sensor network, Personal area network, Data synchronization, Service management, Mobile File system File Systems, Mobility Management, Wireless Application Protocol, Security issues in Mobile.	
Practical and mini-projects will be based on the coverage of the above topics.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

List of Practical (Problem Statements will be changed every year and will be notified on Website)	
1	To understand and learn the basic application development using Android platform and to demonstrate the communication between two different android devices.
2	To set up and analyse the wireless networks system considering multiple nodes and different parameters using network simulation tools.
3	To implement File Transfer, Access and Authentication based applications for mobile computing
4	To compare ad-hoc routing protocols using simulation tools like NS3, Tiny OS, OPNET and OMNET++
5	To work on mini project based on tracking, localization and routing in wireless network.

BOOKS RECOMMENDED

1. William Stallings, "Wireless Communications & Networks", 2nd Ed., Pearson Education India, Reprint 2007.
2. Jochen Schiller, "Mobile Communications", 2nd Ed., Pearson Education India, reprint 2007.
3. T S Rappaport, "Wireless Communications: Principles & Practice", 2nd Ed., Pearson Education, 2002.
4. Raj Kamal, “Mobile Computing”, Oxford University Press, 2007.
5. C. Siva Ram Murthy and B. S. Manoj, “Ad Hoc Wireless Networks: Architectures and Protocols”, Pearson education 2007.

ADDITIONAL BOOKS RECOMMENDED

1. Sandeep Singhal, "The Wireless Application Protocol", Addison Wesley, India, reprint 2001.
2. C E Perkins, "Ad Hoc Networking", Addison Wesley, 2000.
3. Asoke K Talukder, Roopa R Yavagal, “Mobile Computing: Technology, Applications and Service Creation”, Tata McGraw-Hill, Third reprint 2006.
4. Xiaodong Wang, H. Vincent Poor, “Wireless Communication Systems: Advanced Techniques for Signal Reception”, Pearson Education, 2006.
5. Gottapu Sasibhushana Rao, “Mobile Cellular Communication”, Pearson, 2013.

Course Outcomes **At the end of the course, students will**	
CO1	have knowledge of fundamentals of wireless communications and mobile computing.
CO2	be able to apply the knowledge of TCP/IP for designing the systems for mobile and wireless networks.
CO3	be able to analyze security, energy efficiency, mobility, scalability and their unique characteristics in wireless networks.
CO4	be able to evaluate different protocols and mobile application developed for the cellular and ad-hoc wireless networks.
CO5	be able to design and innovate a solution for the issues and problems related to wireless networks and mobile computing.

M. Tech. I (CSE) Semester – II	L	T	P	C
CSCS104: DISTRIBUTED SYSTEMS (CORE -5)	**3**	**0**	**2**	**4**

Course Objective	
1	To learn the principles, architectures, algorithms and programming models used in distributed systems
2	To understand design and implementations issues in distributed systems.
3	To understand scheduling in distributed operating systems, process management, fault tolerance, real-time distributed systems, and designing of distributed file systems
4	To study the distributed resource and process management components.
5	To study advanced topics related to distributed operating systems.

INTRODUCTION TO DISTRIBUTED SYSTEMS	**(04 Hours)**
Review of Networking Protocols, Point to Point Communication, Operating Systems, Concurrent Programming, Characteristics and Properties of Distributed Systems, Goals of Distributed Systems, Multiprocessor and Multicomputer Systems, Distributed Operating Systems, Network Operating Systems, Middleware Concept, The Client-Server Model, Design Approaches-Kernel Based-Virtual Machine Based, Application Layering.	
COMMUNICATION IN DISTRIBUTED SYSTEM	**(05 Hours)**
Layered Protocols, Message Passing-Remote Procedure Calls(RPC), Remote Method Invocation(RMI), Message Oriented Communication, Stream Oriented Communication, Case Studies.	
SYNCHRONIZATION IN DISTRIBUTED SYSTEM	**(09 Hours)**
Clock Synchronization, Logical Clocks, Global State, Election Algorithms-The Bully algorithm-A Ring algorithm, Mutual Exclusion- Centralized Algorithm, Distributed Algorithm, Token ring Algorithm, Distributed Transactions, Distributed deadlock detection.	
DISTRIBUTED SHARED MEMORY	**(06 Hours)**
Introduction, General architecture of DSM systems, Design and implementation issues of DSM, Granularity, Structure of shared memory space, consistency models, Replacement strategy, Thrashing.	
RESOURCE MANAGEMENT	**(06 Hours)**
Desirable features of scheduling algorithm, Task assignment approach, Load balancing and Load sharing approach.	
PROCESS MANAGEMENT	**(04 Hours)**
Concept of Threads, Process, Processor allocation, Process Migration and Related Issues, Software Agents, Scheduling in Distributed System, Load Balancing and Sharing Approaches, Fault tolerance, Real time Distributed System	
DISTRIBUTED FILE SYSTEM	**(05 Hours)**
Introduction, Architecture, Mechanisms for Building Distributed File Systems-Mounting-Caching-Hints-Bulk Data Transfer-Encryption, Design issues-Naming and Name Resolution-Caches on Disk or Main Memory-Writing Policy-Cache consistency-Availability-Scalability-Semantics, Case Studies, Log Structured File Systems	
ADVANCED TOPICS	**(04 Hours)**

Introduction of Security in Distributed OS, Overview of security techniques, Features, Need, Access Control, Security Management, Micro Services Architecture, Lockless Data Structures, Distributed/Scalable Messaging Architecture, AMQP.	
CASE STUDY	**(02 Hours)**
Amoeba, Mach, Chorus and their comparison.	
Practical Assignments will be based on the coverage of above topics.	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

List of Practical (Problem Statements will be changed every year and will be notified on Website.)	
1.	Assignments on Client server-based programs using RPC and RMI.
2.	Practical based on Clock Synchronization.
3.	Practical based on Election, Mutual Exclusion and deadlock algorithms.
4.	Programs based on process/code migration.
5.	Assignments based on Case studies.

BOOKS RECOMMENDED

1. Pradeep Sinha, “Distributed Operating Systems Concepts and Design”, 1st ed., PHI Learning Private Limited, 1998.
2. Andrew Tannebaum, “Distributed Operating Systems” 2nd ed., Pearson, 2013.
3. MukeshSinghal, Niranjan G. Shivaratri, "Advanced Concepts in Operating Systems: Distributed, Database, and Multiprocessor Operating Systems", TMGH, 2011.
4. George Coulouris, Jean Dollimore,TimKindberg ,“Distributed Systems: Concepts and Design”, 5th ed., Pearson, 2017.
5. Andrew Tanebaum, Maarten Steen, “Distributed Systems: Principles and Paradigms”, 2nd Ed.

ADDITIONAL BOOKS RECOMMENDED

1. Sunita Mahajan, Seema Shah, “Distributed Computing”, 2nd ed., Oxford University Press, 2013.

Course Outcomes **At the end of the course, students will**	
CO1	gain clear understanding of fundamental principles of Distributed Operating Systems along with design and implementation of key mechanisms, Clock Synchronization, Election Algorithms, Mutual Exclusion, Message Communication, Process and Resource Scheduling etc.
CO2	be able to apply knowledge of various distributed algorithms for real world problems.
CO3	be able to analyze different advanced architectures.
CO4	be able to evaluate different security techniques for distributed problems.
CO5	be able to design various real life applications using principles and paradigms of Distributed Operating System.

M. Tech. I (CSE) Semester – I	**L**	**T**	**P**	**C**
CSCS111: COMPUTER VISION AND IMAGE PROCESSING (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	To understand the fundamentals image processing and computer vision about image formation, representation and camera calibration.
2	To study various image processing operations and computer vision techniques for camera calibration, depth, motion, stereo and optical flow estimation.
3	To learn different vision based advanced techniques for image understanding and interpreting the images in spatial and frequency domain.
4	To learn different feature extraction and algorithm evaluation techniques for image analysis.
5	To enable student to develop various applications using image processing and computer vision techniques.

LOW LEVEL IMAGE PROCESSING	**(08 Hours)**
Overview of Image and Vision Applications, Illumination, Sampling and Quantization, Image representation and Modeling, Image sources, Image processing application, Image Enhancement, Contrast, Resolution, Histogram Equalization, Spatial Filters, Frequency Representation and Filters, Edge detection, Canny edge detector, Corner detection, Morphological Operation, Color Image Processing, Human eye and cognitive aspects of color, Color transformation.	
HIGH LEVEL IMAGE PROCESSING	**(09 Hours)**
Order statistic filters, Image Segmentation, Object Boundary Detection and Representation, Texture representation, Gabor filters, Noise Removal, Blurring, Image restoration, Image compression.	
IMAGE FORMATION AND RADIOMETRY	**(06 Hours)**
Basics of Image Formation and Radiometry, Bidirectional Reflection Distribution Function, Reflectance Map, Image Formation and Coordinate Transformations, Camera Pin-hole model, Camera calibration, Camera Parameters: Internal and External, Camera Parameters estimation, 3D coordinates and transformation.	
SHAPE AND MOTION ANALYSIS	**(06 Hours)**
Calculus of variation theory, Light at Surfaces, Phong Model, Albedo estimation, Horn-Schunk Optical Flow Formulation, Motion estimation, Epipolar geometry, Photometric Stereo, Structure from motion, Depth from stereo, Shape from Shading, Surface smoothness, Relaxation methods for depth estimation, Shape from texture, 3-D models, Volumetric representation and modeling, Surface modeling.	
IMAGE ANALYSIS AND UNDERSTANDING	**(09 Hours)**
Multi resolution approach, Super resolution, MRF based modeling, Labelling, MRF based applications: Segmentation, Object recognition, Facial detection, Biometric: Iris and Finger print, Feature extraction, Feature vector dimension Reduction, Template based modeling for recognition, Knowledge representation, Feature matching algorithm.	
APPLICATIONS	**(07 Hours)**
Video summarization, In-painting, Biometric recognition, Target detection and tracking, Face recognition, Human gesture and action recognition, Animated Character, Rendering.	
Practical and mini-projects will be based on the coverage of the above topics.	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

List of Practical (Problem Statements will be changed every year and will be notified on Website.)	
1	Implementation of low level, mid-level, and high-level image processing algorithms.
2	Implementation of various filters and transformation techniques for frequency domain operations.
3	Implementation of camera calibration and estimation of internal and external parameters.
4	Implementation of depth using optical flow, stereo and motion.
5	Implementation of application-basedmini-project.

BOOKS RECOMMENDED

1. Rafael C. Gonzales and Richard E. Woods, "Digital Image Processing", 4th edition Education, Reprint 2018.
2. Anil K. Jain, "Fundamentals of Digital Image Processing", PHI, EEE, 4th reprint 2002.
3. David A. Forsyth and Jean Ponce, "Computer Vision: A Modern Approach", Prentice -Hall, 2004.
4. J. R. Parker, " Algorithms for Image Processing and Computer Vision", 2ndedition ,Wiley, 2010.
5. Robert M. Haralick and Linda G. Shapiro, "Computer and Robot Vision ", Addison Wesley, 1992.

ADDITIONAL BOOKS RECOMMENDED

1. Milan Sonka, Vaclav Hlavac, Roger Boyal, “Image Processing Analysis and Machine Vision” 3rdEd. PWS / Thomson Publishing, 2007.
2. Richard Hartley and Andrew Zisserman, “Multiple View Geometry in Computer Vision”, Second Edition, Cambridge University Press, March 2004.

Course Outcomes **At the end of the course, students will**	
CO1	be able to understand fundamentals of image processing and computer vision and image analyzing techniques.
CO2	be able to apply various image processing operations for analyzing images and vision related techniques for segmentation, visualization of depth and camera calibration.
CO3	be able to analyze the problem and effectively use appropriate technique for image processing and vision related problem solving.
CO4	be able to evaluate critically the solutions developed for image processing and vision problems.
CO5	be able to build new applications using advanced image processing and computer vision techniques.

M.Tech. I (CSE) Semester – I	L	T	P	C
CSCS113: ADVANCED DATABASE MANAGEMENT SYSTEMS (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	Enhanced the knowledge in the areas of database management that go beyond traditional (relational) database management systems.
2	Comprehend the query processing efficient information management for Distributed, Parallel and Object Oriented DBMS
3	To understand and implement of web-enabled applications with different programming languages.
4	To enhance the knowledge about spatial data storage and management
5	To understand storage and management issues of the unstructured data.

DISTRIBUTED DATABASE CONCEPTS	(06 Hours)
Overview of client - server architecture and its relationship to distributed databases, Concurrency control Heterogeneity issues, Persistent Programming Languages, Object Identity and its implementation, Clustering, Indexing, Client Server Object Bases, Cache Coherence.	
PARALLEL DATABASES	**(06 Hours)**
Parallel Architectures, performance measures, shared nothing/shared disk/shared memory based architectures, Data partitioning, Intra-operator parallelism, Pipelining, Scheduling, Load balancing	
QUERY PROCESSING	**(06 Hours)**
Index based, cost estimation, Query optimization: algorithms, Online query processing and optimization, XML, DTD, XPath, XML indexing, Adaptive query processing.	
ADVANCED TRANSACTION MODELS	**(06 Hours)**
Savepoints, Sagas, Nested Transactions, Multi Level Transactions. Recovery: Multilevel recovery, Shared disk systems, Distributed systems 2PC, 3PC, replication and hot spares, Data storage, security and privacy Multidimensional K- Anonymity, Data stream management.	
MODELS OF SPATIAL DATA	**(05 Hours)**
Conceptual Data Models for spatial databases (e.g. pictogram enhanced ERDs), Logical data models for spatial databases: raster model (map algebra), vector model, Spatial query languages, Need for spatial operators and relations, SQL3 and ADT. Spatial operators, OGIS queries	
WEB ENABLED APPLICATIONS	**(06 Hours)**
Review of 3-tier architecture - Typical Middle-ware products and their usage. Architectural support for 3 -tier applications: technologies like RPC, CORBA, COM. Web Application server - WAS architecture Concept of Data Cartridges - JAVA/HTML components. WAS	
OBJECT ORIENTED DATABASES	**(05 Hours)**
Notion of abstract data type, object oriented systems, object oriented db design. Expert databases: use of rules of deduction in data bases, recursive rules.	
ADVANCE TOPICS	**(05 Hours)**
No SQL Databases, Unstructured Databases, Couchbase, MongoDB, Cassendra, Redis, Memcached.	
Practical and mini-projects will be based on the coverage of the above topics.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

BOOKS RECOMMENDED
1. R. Elmasri and S. Navathe, Fundamentals of Database Systems, Benjamin- Cummings 98 Edition 5th Edition, 2007. 2. AviSilberschatz, Hank Korth, and S. Sudarshan, Database System Concepts, McGraw Hill Edition 5th Edition, 2005 3. S. Shekhar and S. Chawla, Title Spatial Databases: A Tour, Prentice Hall, Edition 2003 4. Hector Garcia-Molina, Jeff Ullman, and Jennifer Widom, Database Systems, Pearson Edition 2nd Edition 5. Mattison, Rob Mattison, "Web Data Warehousing and Knowledge Management", MGH.

Course Outcomes **At end of the course Student will be able to**	
CO1	understand advanced database techniques for storing a variety of data with various database models.
CO2	to apply various database techniques/functions with Object Oriented approach to design database for real life scenarios.
CO3	Analyse the problem to design database with appropriate database model.
CO4	Evaluate methods of storing, managing and interrogating complex data.
CO5	Develop web application API’s, Distributed databases with the integration of various programming languages.

M. Tech. I (CSE) Semester – I	**L**	**T**	**P**	**C**
CSCS115: HIGH PERFORMANCE COMPUTING (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	To understand fundamentals concepts related to High-Performance Computing and state-of-the-art in Parallel Programming environment
2	To study the architectures of several types of high-performance computers and the implications on the performance of algorithms of these architectures
3	To provide an in-depth analysis of design issues in parallel computing
4	To learn the programming constructs required for parallel programming
5	To learn how to achieve parallelism in CUDA architectures

PARALLEL PROCESSING CONCEPTS	**(10 Hours)**
Levels of parallelism (instruction, transaction, task, thread, memory, function), Models (SIMD, MIMD, SIMT, SPMD, Dataflow Models, and Demand-driven Computation etc.), Architectures: N-wide superscalar architectures, multi-core, multi-threaded, performance file systems, GPU systems, performance clusters.	
DESIGN ISSUES AND CHALLENGES IN PARALLEL COMPUTING	**(10 Hours)**
Synchronization, Scheduling, Job Allocation, Job Partitioning, Dependency Analysis, Mapping Parallel Algorithms onto Parallel Architectures, Performance Analysis of Parallel Algorithms, Bandwidth Limitations, Latency Limitations, Latency Hiding/Tolerating Techniques and their limitations, Power-Aware Computing and Communication, Power-aware Processing Techniques, Power-aware Memory Design, Power-aware Interconnect Design, Software Power Management.	
PARALLEL PROGRAMMING WITH OPENMP AND MPI	**(10 Hours)**
Programming languages and programming-language extensions for HPC, Inter-process communication, Synchronization, Mutual exclusion, Basics of parallel architecture, Parallel programming with OpenMP and (Posix) threads, Message passing with MPI, Thread Management, Workload Manager, Job Schedulers.	
PARALLEL PROGRAMMING WITH CUDA	**(10 Hours)**
Processor Architecture, Interconnect, Communication, Memory Organization, and Programming Models in high-performance computing architectures: (Examples: IBM CELL BE, Nvidia Tesla GPU, Intel Larrabee Microarchitecture and Intel Nehalem microarchitecture), Memory hierarchy and transaction-specific memory design, Thread Organization, OpenCL.	
ADVANCED TOPICS	**(05 Hours)**
Petascale Computing, Optics in Parallel Computing, Quantum Computers.	
Practical and mini-projects will be based on the coverage of the above topics.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

List of Practical (Problem statements will be changed every year and will be notified on the website.)	
1	Implement parallel programming preliminary examples.

2	Implement algorithms using OpenMP and MPI.
3	Implement experiments using CUDA.
4	Implement and evaluate performance HPC algorithms for load distribution, thread management and job scheduling.
5	Implementation of mini-projects in different areas.

BOOKS RECOMMENDED

1. John L. Hennessy and David A. Patterson “Computer Architecture -- A Quantitative Approach”, 4th Ed., Morgan Kaufmann Publishers, 2017, ISBN 13: 978-0-12-370490-0.
2. Barbara Chapman, Gabriele Jost and Ruud van der Pas, “Using OpenMP: portable shared memory parallel programming”, The MIT Press, 2008, ISBN-13: 978-0-262-53302-7.
3. Marc Snir, Jack Dongarra, Janusz S. Kowalik, Steven Huss-Lederman, Steve W. Otto, David W. Walker, “MPI: The Complete Reference”, Volume2, The MIT Press, 1998, ISBN: 9780262571234.
4. Pacheco S. Peter, “Parallel Programming with MPI”, Morgan Kaufman Publishers, 1992, Paperback ISBN: 9781558603394.
5. Shane Cook, CUDA Programming: A Developer's Guide to Parallel Computing with GPUs, Morgan Kaufmann publishers, 2014, ISBN: 9780124159334.

Course Outcomes **At the end of the course, students will**	
CO1	learn concepts, issues and limitations related to parallel computing.
CO2	be able to understand and explain different parallel models of computation, parallel architectures, interconnections and various memory organizations in modern high-performance architectures.
CO3	be able to map algorithms onto parallel architectures for parallelism.
CO4	be able to analyze and evaluate the performance of different architectures and parallel algorithms.
CO5	be able to design and implement parallel programs for shared-memory architectures and distributed-memory architectures using modern tools like OpenMP and MPI, respectively.

M. Tech. I (CSE) Semester – I	L	T	P	C
CSCS117: FOUNDATIONS OF DATA SCIENCE (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	To understand the fundamentals of data analytics, distributed database, foundational skills in data science, including preparing and working with data; abstracting and modeling.
2	To go from raw data to a deeper understanding of the patterns and learn to store, manage, and analyze unstructured data structures within the data, to support making predictions and decision making.
3	To learn processing large data sets using Hadoop and make predictions using machine learning and statistical methods.
4	To learn computational thinking and skills, various text analysis and stream data analysis techniques including the Python programming language for analyzing and visualizing data.
5	To learn various topics such as statistics, crawling data, data visualization, advanced databases, complex data represented using graphs or high dimensional data and cloud computing, along with a toolkit to use with data.

INTRODUCTION	**(06 Hours)**
Overview of Data Science and Big Data, Datafication: Current landscape of Perspectives, Skill Sets needed; Matrices, Matrices to Represent Relations Between Data and Linear Algebraic Operations on Matrices, Approximately Representing Matrices by Decompositions, SVD and PCA; Statistics: Descriptive Statistics: Distributions and Probability, Statistical Inference: Populations and Samples, Statistical Modeling, Fitting a Model, Hypothesis Testing, Introduction to R and Python.	
DATA PREPROCESSING	**(08 Hours)**
Types of Data and Representations, Acquiring Data, Crawling, Parsing Data, Data Manipulation, Data Wrangling, Data Cleaning, Data Integration, Data Reduction, Data Transformation, Data Discretization, Distance Metrics, Evaluation of Classification, Methods: Confusion Matrix, Student's T-tests and ROC Curves, Exploratory Data Analysis, Basic Tools: Plots, Graphs and Summary Statistics of EDA, Philosophy of EDA.	
GRAPH	**(09 Hours)**
Different Types of Graphs, Trees, Basic Concepts Isomorphism and Subgraphs, Multi Graphs and Euler Circuits, Hamiltonian Graphs, Chromatic Numbers, Graph and Tree Processing Algorithms, Graph based Applications	
DATA VISUALIZATION	**(06 Hours)**
Data visualization: Basic Principles and Tools, Graph Visualization, Data summaries, Link analysis, Mining of Graph, High Dimensional Clustering, Recommendation Systems.	
PARADIGMS FOR LARGE SCALE DATA PROCESSING	**(08 Hours)**
MapReduce, Hadoop System, Software Interfaces, e.g., Hive, Pig, Traditional Warehouses vs. MapReduce Technology, Distributed Databases, Distributed Hash Tables, Near-real-tips Query.	
TEXT ANALYSIS	**(08 Hours)**
Data Flattening, Filtering, Chunking, Feature Scaling, Dimensionality Reduction, Nonlinear Futurization, Shingling of Documents, Locality-Sensitive Hashing for Documents, Distance Measures, LSH Families for Other Distance Measures, Collaborative Filtering, Sampling Data in a Stream, Filtering Streams, Counting Distinct Elements in a Stream, Moments, Windows, Clustering for Streams.	
Practical will be based on the coverage of the above topics.	**(30 Hours)**

(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

List of Practical (Problem statements will be changed every year and will be notified on the website.)

1	Practical related to Hadoop Installation and implementations using artificial data.
2	Introduction to software tools for data analytics science.
3	Practical based on Basic Statistics and Visualization.
4	Practical related to data preprocessing and data preparation for various Data mining processes.
5	Practical related to different SQL and NOSQL databases.
6	Practical based on Classification.
7	Practical based on K-means Clustering.
8	Practical related to Big Text analysis.

BOOKS RECOMMENDED

1. Joel Grus, “Data science from scratch”, O'Reilly Media.
2. Avrim Blum, John Hopcroft, and Ravindran Kannan, “Foundations of Data Science”, Cambridge University Press.
3. Anand Rajaraman and Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press.
4. Peter Bruce, Andrew Bruce, ”Practical Statistics for Data Scientists: 50”, O’Reilly publishing house.
5. Douglas C. Montgomery and George C. Runger, “Applied statistics and probability for engineers”, John Wiley & Sons.

ADDITIONAL BOOKS RECOMMENDED

1. Jiawei Han, Micheline Kamber and Jian Pei, “Data Mining: Concepts and Techniques”, Morgan Kaufmann.
2. Mohammed J. Zaki and Wagner Miera Jr, “Data Mining and Analysis: Fundamental Concepts and Algorithms”, Cambridge University Press.
3. Matt Harrison, “Learning the Pandas Library: Python Tools for Data Munging, Analysis, and Visualization, O'Reilly.
4. Tom White, ”Hadoop: The Definitive Guide”, O’Reilly Media.

Course Outcomes
At the end of the course, students will

CO1	be able to understand the principles and purposes of data science, and articulate the different dimensions of the area.
CO2	be able to apply various data pre-processing and manipulation techniques including various distributed analysis paradigms using Hadoop and other tools.
CO3	be able to apply basic data mining machine learning techniques to build a classifier or regression model, and predict values for new examples.
CO4	be able interpret various large datasets by applying Data Mining techniques like clustering, filtering, factorization.
CO5	be able to implement and perform advanced statistical analysis to solve complex and large dataset problems for real life applications.

M. Tech. - I (CSE) Semester – I	L	T	P	C
CSCS119: EMBEDDED SYSTEMS DESIGN (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	To learn about hardware and software design requirements of embedded systems, the processes, methodologies, fundamental problems, and best practices associated with the development of applications in the context of high-performance embedded computing systems.
2	To study several different styles of processors used in embedded systems, the use of interrupts and inter-process communication, techniques for tuning the performance of a processor, and to optimize embedded CPUs.
3	To understand memory system optimizations and the back end of the compilation process to determine the quality of code.
4	To study the importance of embedded multiprocessors, their architectures, design techniques, methodologies, algorithms, IoT, and its applications.
5	To learn various embedded software development tools and provide in-depth knowledge of scheduling algorithms and middleware architectures for multiprocessors and hardware/software co-design and co-synthesis algorithms.

INTRODUCTION: EMBEDDED HARDWARE	**(04 Hours)**
Introduction to embedded systems Hardware needs; typical and advanced, timing diagrams, memories (RAM, ROM, and EPROM) Tristate devices, Buses, DMA, UART and PLD's Built-ins on the microprocessor, Example applications, Design methodologies, Embedded Systems Design flows, Models of computation, Parallelism and computation, Reliable system design, CE architecture.	
INTERRUPTS	**(04 Hours)**
Interrupts basics ISR; Context saving, shared data problem. Atomic and critical section, Interrupt latency.	
SOFTWARE AND OS	**(04 Hours)**
Survey of software architectures, Round Robin, Function queue scheduling architecture, Use of real time operating system, RTOS, Tasks, Scheduler, Shared data reentrancy, priority inversion, mutex binary semaphore and counting semaphore, Parallel execution mechanisms, Superscalar, SMID and Vector processors, Variable performance CPU architectures, CPU Simulation, Automated CPU Design.	
INTER-PROCESS COMMUNICATION	**(05 Hours)**
Inter task communication, message queue, mailboxes and pipes, timer functions, events Interrupt routines in an RTOS environment.	
EMBEDDED COMPUTING	**(07 Hours)**
Embedded design process, System description formalisms, Instruction sets- CISC and RISC, DSP processors, Embedded computing platform- CPU bus, Memory devices, I/O devices, interfacing, designing with microprocessors, debugging techniques, Hardware accelerators- CPUs and accelerators, Accelerator system design, Embedded system software design using an RTOS Hard real-time and soft real-time system principles, Task division, need of interrupt routines, shared data.	
INTERNET OF THINGS	**(05 Hours)**
Introduction, IoT work flow, IoT Protocols: HTTP, CoAP, MQTT, 6 LoWPAN, building IoT applications.	
TOOLS	**(06 Hours)**

Embedded Software development tools. Host and target systems, cross compilers, linkers, locators for embedded systems. Getting embedded software in to the target system, Debugging techniques like JTAGS, Testing on host machine, Instruction set emulators, logic analyzers In-circuit emulators and monitors.	
NETWORK	**(05 Hours)**
Distributed embedded architectures, Networks for embedded systems, Network-based design, and Internet enabled systems.	
SYSTEM DESIGN TECHNIQUES	**(05 Hours)**
Design methodologies, Requirements analysis, System analysis and architecture design, Quality assurance.	
Practical Assignments will be based on the coverage of above topics.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

List of Practical (Problem Statements will be changed every year and will be notified on Website.)	
1	Implement experiment based on programming of Embedded boards.
2	Implement experiment based on Embedded OS.
3	Implement RTOS and job scheduler with Embedded systems.
4	Implement Embedded computing algorithm and evaluate the performance using different tools.
5	Implement mini projects based on Embedded systems for real applications.

BOOKS RECOMMENDED

1. Mohamed Ali Mazidi, Janice GillispieMazidi, RolinMcKinlay, “The 8051 Microcontroller and Embedded Systems: Using Assembly and C”, 2nd Edition, Pearson Education, 2011.
2. Raj Kamal, “Embedded Systems-Architecture, Programming and Design”, 2/E, TMH, 2007.
3. Jonathan W. Valvano, “Embedded Microcomputer Systems-Real Time Interfacing”, Thomson Learning, 2006.
4. David A. Simon, “An Embedded Software Primer”, 1/E,Pearson Education,2001.
5. Louis L. Odette, “Intelligent Embedded Systems”, Addison-Wesley, 1991.

ADDITIONAL BOOKS RECOMMENDED

1. Wayne Wolf,“High-Performance Embedded Computing: Architectures, Applications, and Methodologies“, Morgan Kaufmann, 2006, ISBN-13: 978-0123694850.
2. Larry L Peterson, “Computer Networks: A Systems Approach”, Morgan Kaufmann, 2007, ISBN-13:978-0123705488.
3. Frank Vahid and Tony Givargis, “Embedded System Design: A Unified Hardware/Software Introduction”, John Wiley, 2002.
4. Marilyn Wolf, “Computers as Components- Principles of Embedded Computing System Design”, Morgan Kaufmann, 2016.
5. Denial D. Gajski , Frank Vahid, “Specification and design Embedded systems”, Prentice Hall; Facsimile edition, 1994.

Course Outcomes **At the end of the course, students will**	
CO1	be able to understand hardware-software requirements, interrupts and inter process communication of embedded systems.
CO2	be able to apply techniques for simulating processors, for tuning the performance of a processor and to optimize embedded CPUs, such as code compression and bus encoding. They will be able to use middleware architectures for dynamic resource allocation in multiprocessors.
CO3	be able to analyze the embedded systems' specifications and develop software programs.
CO4	be able to evaluate related software architectures and tools for embedded Systems and evaluate the quality of code using the back end of the compilation process and be able to characterize embedded applications and target architectures using different models.
CO5	be able to design and develop real time embedded systems using the concepts of RTOS.

M. Tech - I (CSE) Semester – I	L	T	P	C
CSCS121: SPEECH AND AUDIO PROCESSING (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	To learn the basics of digital signal processing, analytical methods and it's different applications
2	To understand fundamentals of speech
3	To learn different speech models and speech processing
4	To learn the design of different filters in spatial and frequency domain for speech processing
5	To develop skills for analyzing and synthesizing algorithms and systems for speech recognition, identification, classification for different applications.

BASICS OF DIGITAL SIGNAL	**(06 Hours)**
Analog vs. Digital Signal, Continuous vs. Discrete Signal, Issues with Analog signal processing, Digital signal transmission, Overview of different applications, Fundamentals of z-transform, Fourier transform, Overview of Digital filters: FIR and IIR, Sampling theorem, Decimation and Interpolation.	
FUNDAMENTALS OF SPEECH	**(05 Hours)**
Speech signal, Digital representation of speech, Speech production and perception, Acoustic modeling, Acoustic tubes and features, Acoustic phonetics, Sound propagation, Phase vocoder, Channel vocoder, Vocal tract functioning, Vocal tract transfer function, Time domain models, Frequency domain representation, Concepts of Subband.	
TIME DOMAIN ANALYSIS	**(08 Hours)**
Short time energy and average magnitude, Short time average zero-crossing rate, Pitch period estimation, Speech and silence discrimination, Short time autocorrelation function, Median smoothing, Quantization, Companding, Adaptive Quantization, Delta modulation, Differential PCM.	
FREQUENCY DOMAIN ANALYSIS	**(10 Hours)**
Short time Fourier representation, Short time analysis, Spectrographic, Spectrum analysis, Complex Cepstrum, Pitch Detection, Formant estimation, Linear predictive analysis, LPC equation, solutions, Frequency domain interpretation of Linear Predictive analysis, Relations between various speech parameters, Applications of LPC parameters, IIR and FIR filters design.	
SPEECH MODELING AND PROCESSING	**(16 Hours)**
Vocabulary, Language Modeling, Hidden Markov Models, Pattern Classification and Recognition, Speech Compression, Speech synthesis, Speech recognition, Speaker identification, Emotion analysis, Language identification, Speech Conversion, Speech processing using Neural Networks, Deep Learning.	
Practical and mini-projects will be based on the coverage of the above topics.	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

List of Practical (Problem Statements will be changed every year and will be notified on Website.)	
1	Implementation of basic signal transforms like Fourier, Wavelet and others.
2	Implementation of preliminary feature extractions from speech signals.
3	Implementation of time domain analysis techniques and design of different filters.
4	Implementation of frequency domain analysis techniques and design of different filters.
5	Implementation of advanced techniques of modelling for speech processing.
6	Implementation of application based mini project.

BOOKS RECOMMENDED
1. Lawrence R. Rabiner and Ronald W. Schafer, "Theory and Applications of Digital Signal Processing", Pearson, 2011. 2. Lawrence R. Rabiner and Ronald W. Schafer, "Digital Processing of Speech Signals", Pearson, 2009. 3. Lawrence Rabiner, Biing-Hwang Juang, B. Yegnanarayana, "Fundamentals of Speech Recognition", Pearson, 2009. 4. Douglas O'Shaughnessy, "Speech Communications Human and Machines", Institute of Electrical and Electronics Engineers, 2000. 5. Ben Gold and Nelson Morgan, "Speech and Audio Signal Processing", Wiley, 2006.

ADDITIONAL BOOKS RECOMMENDED
1. M. R. Schroeder, "Computer Speech: Recognition, Compression, Synthesis", Springer Series in Information Science,2nd edition 2004.

Course Outcomes **At the end of the course, students will**	
CO1	be able to understand the process of converting the continuous-time signal into digital signal, process it and convert back to continuous-time signal
CO2	be able to apply the different digital filters to design speech processing applications
CO3	be able to analyse the speech in time domain and frequency domain and also able to analyse tools like Fourier transform and z-transform to find a system's frequency response or system's impulse response
CO4	be able to evaluating the performance of a speech processing based systems like speech recognition, speech identification and many more
CO5	be able to design robust and efficient the speech models and speech processing systems

M.Tech. I (CSE) Semester – I	L	T	P	C
CSCS123: CLOUD COMPUTING AND BIG DATA ANALYTICS (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	To Understand the cloud computing and Big data platform and its use cases.
2	To identify the techniques achieving cloud based big data analytics with scalability and streaming capability.
3	To apply different algorithms and techniques of big data analytics using appropriate cloud platform to solve complex problems.
4	To analyse and evaluate suitable cloud paradigm and big data analytics algorithms and techniques to give solution for complex problem.
5	To design and give solution for given problem through big data analytics tools and cloud platform.

INTRODUCTION	**(09 Hours)**
History and introduction of Cloud Computing, Big Data Analytics, Data Warehousing, Data Mining	
CLOUD COMPUTING	**(09 Hours)**
Virtualization, SOA, Programming Model, Resource Management and Scheduling, Application building for Managing and Analyzing Data	
BIG DATA ANALYTICS	**(09 Hours)**
Concepts and Techniques in Data Warehousing, Concept Description and Association Rule Mining, Classification and Prediction, Hadoop Map-Reduce Platforms, Stream Computing Platforms and Algorithms	
NOSQL DATABASES AND SCALABLE DATA STORAGE	**(09 Hours)**
Graph databases, Mongo and Cassandra	
ADVANCED TOPICS	**(09 Hours)**
Structured and high dimensional data, Real time stream analytics, Generalized functional decomposition, Apache Spark and Storm	
Practical Assignments will be based on the coverage of above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

BOOKS RECOMMENDED

1. J. Leskovec, A. Rajaraman, J. D. Ullman, “Mining of Massive Datasets”, Cambridge.
2. T. White, “Hadoop: The definite guide”.
3. M. Parsian, “Data algorithms: Recipes for scaling up with Hadoop and Spark”.
4. K. Hwang, M. Chen, “Big-Data Analytics for Cloud, IoT and Cognitive Computing”, Willey.
5. Nikos Antonopoulos, Lee Gillam: "Cloud Computing: Principles, Systems and Applications", Springer.

ADDITIONAL BOOKS RECOMMENDED

1. Rajkumar Buyya, James Broberg, Andrzej M. Goscinski: "Cloud Computing: Principles and Paradigms", Wiley.

Course Outcomes At the end of the course, students will	
CO1	have the knowledge of concepts, technologies, architecture and applications cloud computing and big data analytics.
CO2	be able to identify techniques achieving cloud based big data analytics with scalability and streaming capability.
CO3	be able to apply different algorithms and techniques of big data analytics using appropriate cloud platform to solve complex problems.
CO4	be able to analyse and evaluate suitable cloud paradigm and big data analytics algorithms and techniques to give solution for complex problem.
CO5	be able to design and give solution for given problem through big data analytics tools and cloud platform.

M.Tech-I (CSE) Semester – I	L	T	P	C
CSCS125: PRINCIPLES OF INFORMATION SECURITY AND PRIVACY (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	To UNDERSTAND the basic principles of Information Security & Privacy management.
2	To UNDERSTAND the basic concepts of the technical components involved in implementing of the security & privacy.
3	To UNDERSTAND that ensuring information security & privacy in a modern organization is a problem for the management to solve and not one that the technology alone can address.
4	To ANALYZE the important economic and commercial consequences of devising security and privacy solutions in an enterprise or the lack thereof.

INTRODUCTION	**(04 Hours)**
Introduction to Information Security and Privacy: Review of the essential terminologies, basic concepts of security and privacy. Relation or lack thereof between the Information Security, Network Security, Systems Security and the Cyber Security. Key principles of Information Security in terms of Security mechanisms, security attributes and the security attacks. Role of National Security Systems (CNSS) and CERTIN. The McCumber Cube for Security. Introduction to the Security Systems Development Life Cycle and the difference between the Software Security and the Security Software. Classical Security Models.	
SECURITY THREATS AND SECURITY ATTACKS	**(03 Hours)**
Taxonomy of Security attacks. Illustrations of typical attacks. Cyber security threats. The basic terminologies viz. threats, defects, vulnerabilities, exploits, attacks, bugs.	
INTRODUCTION TO INFORMATION PRIVACY	**(05 Hours)**
The importance of Data privacy; Privacy rules; Data Protection – Organization Roles. Approaches to protect sensitive data. Personally, Identifiable Information and Sensitive Data. Data Privacy and Protection Responsibilities. Consequences of Privacy Unawareness. Overview of Global Data Privacy Laws. The DSCI Privacy Framework for global privacy best practices and frameworks.	
SECURITY TECHNOLOGY – I	**(06 Hours)**
Security Mechanisms: The Symmetric and Asymmetric Key Cryptography, Ciphers: Cryptographic Algorithms and the Cryptosystems, Mechanisms for Data Integrity and Entity Authentication, Access Control mechanisms.	
SECURITY TECHNOLOGY – II	**(06 Hours)**
Cryptographic Tools: The Public-Key-Infrastructure (PKI), Digital Signatures, Digital Certificates, Hybrid Cryptographic Systems, Steganography. The Public Key Cryptography (PKC) limitations and looking beyond the PKC.	
SECURITY TECHNOLOGY – III	**(06 Hours)**
Protocols for Secure Communications: HTTPS, TLS for Secure Internet Communication, S/MIME, PEM, PGP for Secure Email, the SET, TLS, and HTTPS for Securing Web Transactions, WEP and WPA for Secure Wireless Communications, Securing TCP/IP with IPSec PGP.	
SECURITY TECHNOLOGY – IV	**(06 Hours)**
Firewalls: Processing Modes, Categorized by Generations, by Structure, Architectures, Selecting the right firewall, Configuring and Managing Firewalls. Remote Access, the concept of Virtual Private Networks.	
SECURITY TECHNOLOGY – V	**(06 Hours)**

Intrusion Detection and Prevention Systems: Why use IDPSs, Types, IDPSs Detection Methods, IDPS Response Behaviour, IDPS Approaches. Strenghts and Limitations. Deployment and Implementation of IDPSs. Measuring the effectiveness of IDPSs. Honeypots, Honeynets and Padded Cell Systems. Network Reconnaissance: Network Scanning and Analysis.	
OTHER TOPICS	**(03 Hours)**
Legal and Ethical Issues in Information Security and Privacy. Introduction to Cyber Laws. Introduction to Security policies and Security Acts.	
Practical Assignments will be based on the coverage of above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

BOOKS RECOMMENDED

1. Principles of Information Security, By Michael E. Whitman, Herbert J. Mattord, Course Technology Press, 4th edition, 2011
2. Computer Security, by Dieter Gollmann, Wiley, 3rd edition, 2014
3. Principles of Information Systems Security: Texts and Cases, By GurpreetDhillon, John Wiley & Sons, 1st edition, 2006
4. Information Security Management Principles, by Andy Taylor, David Alexander, Amanda Finch, David Sutton, 3rd edition, BCS, The Chartered Institute for IT Publishers, 2020
5. Cyber Security: A practitioner's guide, by David Sutton, BCS, The Chartered Institute for IT Publishers, 2017

Course Outcomes **At the end of the course, students will be able to**	
CO1	Understand the fundamental techniques of computer security.
CO2	Examine and apply and identify potential security issues and the associated risks.
CO3	Demonstrate responsible computer use as it deals with social, political, legal and ethical issues in today's electronic society.
CO4	Demonstrate foundation knowledge of information security/assurance within the organization.
CO5	Plan for the future and design a solution based on user requirements. Explain business continuity, backup and disaster recovery. Understand troubleshooting and quality consumer support.

M. Tech. I (CSE) Semester – I	**L**	**T**	**P**	**C**
CSCS127: RESEARCH METHODOLOGY IN CSE (CORE ELECTIVE-1 OR 2)	**3**	**1**	**0**	**4**

Course Objective	
1	To understand the basic terminology of research, and its methodology and learn different methodologies of pursuing the research in terms of organization, presentation and evaluation.
2	To apply the concept in writing the technical content.
3	To analyze the existing method using different parameters in different scenarios.
4	To evaluate the proposed work and compare it with the existing approach systematically using the appropriate methodology, through simulation depending upon the research field.
5	To design algorithms using concepts learned and write reports and papers technically and grammatically correct.

INTRODUCTION	**(04 Hours)**
Research: Definition, Characteristics, Motivation and Objectives, Research Methods vs Methodology, Types of Research – Descriptive vs Analytical, Applied vs Fundamental, Quantitative vs Qualitative, Conceptual vs Empirical.	
METHODOLOGY	**(04 Hours)**
Research Process, Formulating the Research Problem, Defining the Research Problem, Research Questions, Research Methods vs. Research Methodology.	
LITERATURE REVIEW	**(04 Hours)**
Review Concepts and Theories, Identifying and Analyzing the Limitations of Different Approaches.	
FORMULATION AND DESIGN	**(05 Hours)**
Concept and Importance in Research, features of a Good Research Design, Exploratory Research Design, Concept, Types and Uses, Descriptive Research Designs, Concept, Types and Uses, Experimental Design: Concept of Independent & Dependent Variables.	
DATA MODELING AND SIMULATIONS	**(08 Hours)**
Mathematical Modeling, Experimental Skills, Simulation Skills, Data Analysis and Interpretation.	
TECHNICAL WRITING AND TECHNICAL PRESENTATIONS	**(05 Hours)**
CREATIVITY AND ETHICS IN RESEARCH, INTELLECTUAL PROPERTY RIGHTS	**(05 Hours)**
TOOLS AND TECHNIQUES FOR RESEARCH	**(06 Hours)**
Methods to Search Required Information Effectively, Reference Management Software, Software for Paper Formatting, Software for Detection of Plagiarism.	
DISCUSSION AND DEMONSTRATION OF BEST PRACTICES	**(04 Hours)**
(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

BOOKS RECOMMENDED

1. John W. Creswell, “Research Design: Qualitative, Quantitative, and Mixed Methods Approaches”, SAGE Publications Ltd.
2. C.R. Kothari,”Research Methodology: Methods and Techniques”, New Age International Publishers.
3. David Silverman,”Qualitative Research”, SAGE Publications Ltd.
4. Norman K. Denzin and Yvonna Sessions Lincoln,” Handbook of Qualitative Research”, SAGE

Publications Ltd.
5. Michael Quinn Patton," Qualitative Research and Evaluation Methods", SAGE Publications Ltd.

Course Outcomes **At the end of the course, students will**	
CO1	to understand the different research methodologies in different areas.
CO2	be able to apply the concepts in writing, presentation, and simulating different experiments.
CO3	be able to analyze the proposed work with existing approaches in the literature and interpret the research design through project development and case study analysis using appropriate tools.
CO4	be able to execute the technical presentation, and organization in writing the report and papers.
CO5	be able to design the algorithms and proof learned and communicate effectively through proper organization and presentation.

M.Tech. I (CSE) Semester – I	**L**	**T**	**P**	**C**
CSCS129: PROBABILISTIC GRAPHICAL MODELS (CORE ELECTIVE-1 OR 2)	**3**	**1**	**0**	**4**

Course Objective	
1	To understand probability, statistics and graph models.
2	To understand different graphical models for solving real time applications in different fields.
3	To be able to learn the design of different types of network based on graphical models.
4	To be able to model problems using graphical models, design inference algorithms, and learn the structure of the graphical model from data.
5	To learn analysis of the problems for developing their solution, correctness and performance using graphs and statistical methods.

INTRODUCTION TO PROBABILITY THEORY	**(06 Hours)**
Random variables and Joint distributions, Marginal distribution, Conditional probability, Expectation and variance, Functions of random variable, Sum of independent random variable, Correlation and regression, Probability Distributions.	
GRAPH THEORY	**(06 Hours)**
Graphs, Different types of Graphs, Isomorphism and Subgraphs, Multigraphs and Euler Circuits, Hamiltonian graphs, Chromatic Numbers, Algorithms for Graphs Processing, Graph representation, Graph Applications.	
GRAPHICAL MODELS	**(09 Hours)**
Directed models: Bayesian network, Undirected model: Markov Random Fields, Dynamic model: Hidden Markov Model, Conditional Independence, Markov Blanket, Factorization, Equivalence, Hybrid Networks, Template based representation.	
INFERENCE IN GRAPHICAL MODELS	**(09 Hours)**
Exact Inference, Belief Propagation, Approximate Inference, Expectation Propagation, Gaussian Belief Propagation, MAP Inference, Sampling - Markov Chain Monte Carlo, Metropolis Hastings, Gibbs, Particle filtering.	
LEARNING IN GRAPHICAL MODELS	**(09 Hours)**
Parameter estimation, Expectation Maximization, Factor Graph, Bayes Ball theorem and D-separation, Hammersley-Clifford theorem, Inference in graphical models, Belief propagation, Viterbi algorithm, Inference, Optimization. MAP Inference, Inference in Hybrid Networks.	
APPLICATIONS BASED ON GRAPHICAL MODELS	**(06 Hours)**
Actions and Decisions, Structured Decision Problems, Graphical models in Network Analysis, Image Processing, Social Network Analysis.	
Practical Assignments will be based on the coverage of above topics.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

List of Practical (Problem statements will be changed every year and will be notified on the website.)	
1	Implement graph traversing algorithms.
2	Implement Markov Random Field based applications.
3	Implement Hidden Markov based applications.
4	Implement Bayesian Network based applications.

BOOKS RECOMMENDED

1. Murray R. Spiegel, John J. Schiller and R. Alu Srinivasan, Theory and Problems of Probability and Statistics, 2nd Edition, Tata McGraw-Hill, 2007.
2. D. Koller and N. Friedman, Probabilistic Graphical Models: Principles and Techniques, MIT Press, 2009.
3. F. V. Jensen and T. D. Nielsen, Bayesian Networks and Decision Graphs, Information Science and Statistics, Springer, 2nd Edition, 2002.
4. A. Papoulis and S. U. Pillai, Probability, Random Variables and Stochastic Processes, 4th Edition, Mc-Graw Hill, 2002.
5. Richard E. Neapolitan, "Learning Bayesian Networks, Prentice Hall Series in Artificial Intelligence, 2003.

Course Outcomes **At the end of the course, students will**	
CO1	be able to acquire knowledge about different terminologies of graphs and statistics.
CO2	be able to apply graph-theoretic models to solve problems of connectivity and constraint satisfaction for different problems.
CO3	be able to analyze the problems for developing the solution, its correctness and performance using graphs and statistics methods learned.
CO4	be able to evaluate the solution built using different graph based modeling.
CO5	be able to design an efficient solution using statistical methods and a variety of graphs for real world problems.

M.Tech. I (CSE) Semester – I	**L**	**T**	**P**	**C**
CSCS131: ARTIFICIAL INTELLIGENCE (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	To introduce the basic concepts of Artificial Intelligence (AI), with illustrations of current state of the art research, tools and applications.
2	To understand the basic areas of AI including problem solving, knowledge representation, heuristic, reasoning, decision making, planning and statistical methods.
3	To identify the type of an AI problem and apply it for search inference, decision making under uncertainty, game theory etc.
4	To describe the knowledge representation techniques, strengths and limitations of various state-space search algorithms, and choose the appropriate algorithm.
5	To introduce advanced topics of AI such as planning, Bayes networks, natural language processing and Expert systems.

INTRODUCTION TO AI AND INTELLIGENT AGENTS	**(05 Hours)**
Basic concepts of Intelligence, Scope and View of AI, Applications of AI, Turing Test, Intelligent Behavior, Intelligent Agents, AI Techniques, AI-Problem formulation, AI Applications, Production Systems, Control Strategies.	
PROBLEM SOLVING	**(08 Hours)**
Defining the problems as a State Space Search and Production Systems, Production Characteristics, Production System Characteristics, And issues in the Design of Search Programs, Additional Problems. Informed and uninformed search strategies: Generate-And-Test, Breadth first search, Depth first search, Hill climbing, Best first search, A* algorithm, AO* Algorithm, Iterative Deepening Search, IDA*, Recursive Best First Search, Constraint propagation, Neural, Stochastic, and Evolutionary search algorithms, Constraint Satisfaction and Heuristic Repair, Applications.	
KNOWLEDGE REPRESENTATION AND REASONING	**(07 Hours)**
Knowledge representation - Production based system, Frame based system, Knowledge representation using Predicate logic, Introduction to predicate calculus, Rule based representations, Declarative / Logical formalisms, Knowledge bases and Inference, Reasoning in uncertain environments, Logic-Structured based Knowledge representation, Inference – Backward chaining, Forward chaining, Rule value approach, Fuzzy reasoning – Certainty factors, Bayesian Theory-Bayesian Network-Dempster – Shafer theory, Symbolic Logic under Uncertainty : Non-monotonic Reasoning, Logics for non-monotonic reasoning, Statistical Reasoning : Probability and Bayes Theorem, Certainty factors, Probabilistic Graphical Models, Bayesian Networks, Markov Networks.	
GAME PLAYING AND PLANNING	**(07 Hours)**
Introduction, Example Domain: Overview, MiniMax, Alpha-Beta Cut-off, Refinements, Iterative deepening, The Blocks World, Components of a Planning System, Goal Stack Planning, Nonlinear Planning Using Constraint Posting, Hierarchical PlanniArtificialIntelligenceng, Reactive Systems, Other Planning Techniques, Recent applications.	
MULTI GAME THEORY	**(08 Hours)**

Introduction, Behavioral game theory: Dictator, Ultimatum and trust games, Mixed strategy equilibrium, Bargaining, Dominant solvable games, Coordination games, Signaling and reputation, Types of learning Reinforcement, Belief, Imitation, Stochastic game theory, Evolutionary games and Markov games for multi-agent reinforcement learning, Economic Reasoning and Artificial Intelligence, Designing games: Cooperative games, Voting, Auctions, Elicitation, Scoring rules, Decision Making and Utility Theory, Adaptive decision making, Analyzing games: Combinatorial games, Zero-sum games, General-sum games, Nash Equilibrium, Correlated Equilibrium, Price of anarchy.

EXPERT SYSTEMS	**(10 Hours)**
Expert Systems – Architecture of Expert Systems, Roles of Expert Systems – Knowledge Acquisition – Meta Knowledge, Heuristics, Typical Expert Systems – MYCIN, DART, XOON, Expert Systems Shells.	
Practical Assignments will be based on the coverage of above topics.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

List of Practical (Problem statements will be changed every year and will be notified on the website.)	
1	Introduction to PROLOG programming.
2	Implement Informed and uniformed based search techniques.
3	Implement various algorithms based on game theory.
4	Practical based on fuzzy logic-based application.
5	Practical based on statistical methods.
6	Implement an expert system for real applications.
7	Practical based on multilayer perceptron.
8	Implement neural network-based application

BOOKS RECOMMENDED

1. Stuart Russell and Peter Norvig, “Artificial Intelligence: A Modern Approach”, Third edition, Prentice-Hall, 2009.
2. Nils J. Nilsson, “Artificial Intelligence: A New Synthesis”, Morgan-Kaufmann, 1998.
3. Elaine Rich and Kevin Knight, “Artificial Intelligence”, 2nd Edition, Tata McGraw-Hill, 2003.
4. W. Patterson, ‘Introduction to Artificial Intelligence and Expert Systems’, Prentice Hall of India, 2010.
5. I. Bratko, "Prolog Programming for Artificial Intelligence", 3/E, Addison-Wesley, 2001.

ADDITIONAL BOOKS RECOMMENDED

1. Donald A.Waterman, “A Guide to Expert Systems”, Pearson Education, 1985, ISBN: 0-201-08313-2.
2. David Poole, Alan Mackworth, “Artificial Intelligence: Foundations for Computational Agents”, Cambridge Univ. Press, 2010.
3. J. Han and M. Kamber, “Mining: Data Concepts and Techniques”, 3rd Edition, Morgan Kaufman, 2011.
4. Hastie, Tibshirani, Friedman, “The elements of statistical learning”, second edition, Springer, 2009.

Course Outcomes **At the end of the course, students will**	
CO1	be able to understand foundational principles, mathematical tools, program paradigms and fundamental issues, challenges of artificial intelligence, formal methods of knowledge representation, logic and reasoning.
CO2	be able to apply intelligent agents for artificial intelligence programming techniques, Fuzzy logic for problem solving and semantic rules for reasoning and inference to real world problems.
CO3	be able to analyze and formalize the problem as a state space, graph, design heuristics and select amongst different search or game-based techniques to solve them.
CO4	be able to evaluate the performance of an informed and uninformed search strategies, fuzzy logic, and expert system and connectionist models based systems.
CO5	be able to design the application on different artificial intelligence techniques like heuristic, game search algorithms, fuzzy, expert system and neural network.

M.Tech. I (CSE) Semester – I	L	T	P	C
CSCS133: CYBER PHYSICAL SYSTEMS (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective:	
1	To have an understanding of the cyber physical systems and the corresponding important research challenges in this area.
2	To be able to learn the evolution in computing from mainframe computing to the ubiquitous and pervasive computing and the dominant role of the embedded systems.
3	To be able to understand various modelling formalisms for the CPSs, viz. Timed and Hybrid Automata and do the formal analysis using flow pipe construction, reachability analysis of CPS Software.
4	To be able to analyze and design the protocols used in resource constrained environments.
5	To be able to improve the critical reading, presentation, and research skills.

INTRODUCTION	**(04 Hours)**
Introduction to Cyber-Physical Systems. The Industrial Revolution 4.0. Motivation for the IR 4.0. Cyber-Physical Systems (CPS) in the real world.	
WIRELESS SENSOR NETWORK AND INTERNET OF THINGS	**(10 Hours)**
Basic principles of design and validation of CPS. Basic characteristics of the CPSs. The Internet of Things. The Industrial Internet of Things. The Wireless Sensor Networks and the RFID devices as the actors of the CPSs. The Ubiquitous and the Pervasive Computing paradigm introduced by the CPSs. The Applications of the Wireless Sensor Networks. The role of the Internet of Things in realizing Smart Applications. The Characteristics and the issues of deployment.	
CPS HARDWARE	**(09 Hours)**
CPS Hardware Platforms: Processors. Types of Processor, The Processors Design issues. Parallelism. Embedded Processors. Harvard Architecture: Pros and Cons. The Sensors and Actuators. Models of Sensors and Actuators. Common Sensors. Actuators. Memory Architectures. Memory Technologies. Memory Hierarchy. Memory Models. Types of memory in the CPSs. Input and Output Hardware. The design issues. The Analog to Digital convertor.	
CPS OPERATING SYSTEMS AND NETWORKING	**(09 Hours)**
Realtime Operating Systems for the WSN devices. Characteristics. Issues. Thread Scheduling. Basics of Scheduling. Rate Monotonic Scheduling. The Earliest Deadline First Scheduling. Scheduling and Mutual Exclusion. Multiprocessor Scheduling. Sequential Software in a Concurrent World. Multitasking. Imperative Programs. Case studies of the typical OSs. TinyOS, nesC and Contiki. The Simulators for the WSN devices. The CPS Network - WirelessHart, CAN, Automotive Ethernet.	
CPS MODELLING AND ANALYSIS	**(09 Hours)**
Formal Methods for Safety Assurance of Cyber-Physical Systems: Advanced Automata based modelling and analysis, Basic introduction and examples, Timed and Hybrid Automata, Definition of trajectories, Formal Analysis: Flow pipe construction, reachability analysis. Analysis of CPS Software: Weakest Preconditions, Bounded Model checking, CPS software verification: Frama-C, CBMC	
CPS SECURITY	**(04 Hours)**
Secure Deployment of CPS: Attack models, Secure Task mapping and Partitioning, State estimation	

for attack detection Automotive Case study: Vehicle ABS hacking Power Distribution Case study: Attacks on SmartGrids.	
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED

1. E. A. Lee and S. A. Seshia, "Introduction to Embedded Systems - A Cyber-Physical Systems Approach", Second Edition, The MIT Press, 2017.
2. Rajeev Alur, "Principles of Cyber-Physical Systems", MIT Press, 2015.
3. ZEADALLY S and NafaâJabeur, "Cyber Physical System Design With Senor Networking Technologies", IET Press, 2016.
4. Taha, W. M., Taha, A. M., Thunberg, J. ,"Cyber-Physical Systems: A Model-Based Approach" , Germany: Springer International Publishing, 2020
5. Rajkumar, R., de Niz, D., Klein, M, "Cyber-Physical Systems". United Kingdom: Pearson Education, 2016.

Course Outcomes At the end of the course, students will be able to	
CO1	Understand the fundamentals of cyber-physical systems (CPS).
CO2	Apply the concepts of CPS to the different paradigms of computing.
CO3	Analyze the design issues associated with different hardware functional units of the CPSs.
CO4	Evaluate the performance impact of thread scheduling algorithms in the CPSs.
CO5	Design CPS solutions for different application domains.

M.Tech. I (CSE) Semester – I	**L**	**T**	**P**	**C**
CSCS135: DIGITAL FORENSICS (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	To understand the basics of digital forensics and different cyber-crimes.
2	To identify the need of digital forensic and role of digital evidences used to investigate the cyber-crime.
3	To understand the system activity logs to perform the scripting for investigating cyber-crime.
4	To investigate digital evidences such as the data acquisition, identification analysis and techniques for conducting the forensic examination on different digital devices.
5	To learn the various tools to perform the operations on data in order to assess the cyber crime

INTRODUCTION	**(06 Hours)**
Introduction to Digital Forensics, Definition and Types of Cybercrimes, Rules for Digital Forensic, Need for Digital Forensics, Types of Digital Forensics, Ethics in Digital Forensics, Introduction to Internet Crimes, Hacking and Cracking, Credit Card and ATM Frauds, Web Technology, Cryptography.	
CYBER CRIME AND DIGITAL EVIDENCES	**(08 Hours)**
Types of Digital Evidences and their Characteristics, Electronic Evidence and Handling, Challenges in Digital Evidence Handling, Searching and Storage of Electronic Media, Emerging Digital Crimes and Modules, Understanding Law Enforcement Agency Investigations, Following the Legal Process, Understanding Corporate Investigations, Establishing Company Policies.	
COMPUTER SECURITY INCIDENT RESPONSE	**(07 Hours)**
Introduction to Computer Security Incident, Goals of Incident Response, Incident Response Methodology, Formulating Response Strategy, Incidence Response Process, Data Collection on Unix Based Systems.	
DISK AND FILE SYSTEM ANALYSIS	**(08 Hours)**
Media Analysis Concepts, File System Abstraction Model, Partition Identification and Recovery, Virtual Machine Disk Images, Forensic Containers Hashing, Carving, Forensic Imaging, Data Analysis Methodology, Investigating Applications, Malware Handling.	
IDENTIFICATION OF DATA	**(08 Hours)**
Identification of Data: Timekeeping, Forensic Identification and Analysis of Technical Surveillance Devices, Reconstructing Past Events, Useable File Formats, Unusable File Formats, Converting Files, Investigating Network Intrusions and Cyber Crime, Network Forensics and Investigating Logs, Investigating Network Traffic, Investigating Web Attacks, Router Forensics. Cyber Forensics Tools and Case Studies.	
NETWORK FORENSICS	**(08 Hours)**
Technical Exploits and Password Cracking, Analyzing Network Traffic, Collecting Network Based Evidence, Evidence Handling, Investigating Routers, Handling Router Table Manipulation Incidents, Using Routers As Response Tools.	
Practical Assignments will be based on the coverage of above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED
1. Jason Luttgens, Matthew Pepe, Kevin Mandia, "Incident Response and computer forensics", Tata McGraw Hill, 2014. 2. Nilakshi Jain, DhananjayKalbande, "Digital Forensic: The fascinating world of Digital Evidences", Wiley, 2016. 3. C. Altheide& H. Carvey, "Digital Forensics with Open Source Tools, Syngress", 2011. ISBN: 9781597495868. 4. Angus M.Marshall, "Digital forensics: Digital evidence in criminal investigation", John – Wiley andSons, 2008. 5. Amelia Phillips, Bill Nelson, Christopher Steuart, "Guide to Computer Forensics and Investigations", Fourth Edition, Course Technology, 2009.

Course Outcomes **At the end of the course, students will**	
CO1	have the knowledge of various cybercrimes and the concepts of digital forensic, and handling evidences.
CO2	be able to apply appropriate response Strategy and the overall incidence response process.
CO3	be able to analyze the data and handling of malware.
CO4	be able to evaluate difference evidences and methodologies for forensic analysis.
CO5	be able to design the digital forensic system to carry out system level forensics for cybercrimes.

M.Tech. I (CSE) Semester – I	L	T	P	C
CSCS137: MACHINE LEARNING FOR SECURITY (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objectives	
1	to describe the fundamental concepts of machine learning for devising security mechanisms.
2	to enumerate the techniques for intrusion detection and malware detection and analysis using machine learning.
3	to learn the machine learning techniques for network traffic analysis
4	to analyse the machine learning approaches for security for probable abuse by the adversary.
5	to design secure machine learning based schemes for malware detection and intrusion detection.

INTRODUCTION & REVIEW OF THE MACHINE LEARNING BASICS **(04 Hours)**

Review of the basic concepts in Linear Algebra, Probability and Statistics. Introduction to the ML techniques. Machine Learning problems viz. Classification, Regression, Clustering, Association rule learning, Structured output, Ranking. The Supervised and Unsupervised learning algorithms. Linear Regression, Gradient descent for convex functions, Logistics Regression and Bayesian Classification Support Vector Machines, Decision Tree and Random Forest, Neural Networks, DNNs , Ensemble learning. Principal Components Analysis. Un-supervised learning algorithms: K-means for clustering problems, K-NN (k nearest neighbors). Apriori algorithm for association rule learning problems. Generative vs Discriminative learning. Empirical Risk Minimization, loss functions, VC dimension. Data partitioning (Train/test/Validation), cross-validation, Biases and Variances, Regularization.

MACHINE LEARNING FOR SECURITY **(05 Hours)**

Introduction to Information Assurance. Review of Cybersecurity Solutions: Proactive Security Solutions, Reactive Security Solutions: Misuse/Signature Detection, Anomaly Detection, Hybrid Detection, Scan Detection. Profiling Modules. Understanding the Fundamental Problems of Machine-Learning Methods in Cybersecurity. Incremental Learning in Cyberinfrastructures. Feature Selection/Extraction for Data with Evolving Characteristics. Privacy-Preserving Data Mining. Motivation for ML in security with real-world case studies. Topics of interest in applications of machine learning for security.

MACHINE LEARNING TECHNQIUES FOR INTRUSION DETECTION **(08 Hours)**

Emerging Challenges in Cyber Security for Intrusion Detection: Unifying the Current Anomaly Detection Systems, Network Traffic Anomaly Detection. Imbalanced Learning Problem and Advanced Evaluation Metrics for IDS. Reliable Evaluation Data Sets or Data Generation Tools. Privacy Issues in Network Anomaly Detection. Machine Learning Techniques: for Anomaly Detection, for Misuse/Signature detection, for Hybrid detection, for Scan detection.Cost-Sensitive Modeling for Intrusion Detection. Data Cleaning and Enriched Representations for Anomaly Detection in System Calls.

MACHINE LEARNING TECHNQIUES FOR MALWARE ANALYSIS **(08 Hours)**

Emerging Cyber Threats in malwares: Threats from Malware, Botnets, Cyber Warfare, Mobile Communication. Cyber Crimes. Malware Analysis: Feature generation, Features to Classification.

Taxonomy of malware analysis approaches based on machine learning. Malware Detection, Similarity Analysis, Category Detection. Feature Extraction. PE Features. Supervised, Unsupervised and Semi-supervised learning algorithms for Malware Detection. Using Deep Learning Approaches: Generative Adversarial Networks.	
NETWORK TRAFFIC ANALYSIS & WEB ABUSE DETECTION	**(08 Hours)**
Machine Learning for Profiling Network Traffic: Theory of Network defense (access control, authentication, detecting in-network attackers, data-centric security, honeypots), Predictive model for classifying network attacks.	
MACHINE LEARNING IN PRIVACY PRESERVATION	**(06 Hours)**
k-anonymity; l-diversity; deferentially private data storage/release; verifiable differential privacy; privacy-preserving inference of social networking data; privacy-preserving recommender system; privacy versus utility. Machine learning techniques for Privacy Preserving Data Mining.	
ADVERSARIAL MACHINE LEARNING	**(06 Hours)**
Adversarial Machine Learning: Motivation and Background. Practical Scenarios and Examples. Modelling the Adversary: Attack Surface Adversary Goals Adversary capabilities. Taxonomy of Adversarial Attacks on Machine Learning: Influence Specificity Security Violation. Data poisoning; Perturbation; Defense mechanism; Generative Adversarial Networks. A peep into Industry Perspectives: Theme of inference Secure Software Development Life Cycle or Secure Development Cycle. Key Inferences in terms of Security gaps, Suggested panacea.	
Practical Assignments will be based on the coverage of above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED

1. Clarence Chio, David Freeman. Machine Learning and Security. Protecting Systems with Data and Algorithms, O'Reilly Media Publications. 2018
2. Marcus A. Maloof (Ed.) , Machine Learning and Data Mining for Computer Security: Methods and Applications, Springer-Verlag London Limited, 2006
3. SumeetDua and Xian Du. Data Mining and Machine Learning in Cybersecurity. CRC Press, Taylor and Francis Group, LLC. 2011
4. Research Papers Prescribed in the class.
5. Fei Hu, Xiali Hei, "AI, Machine Learning and Deep Learning: A Security Perspective", United States: CRC Press, 2023.

Course Outcomes
At the end of the course, students will

CO1	have a knowledge of the limitations of the conventional security software in the wake of machine learning based attacks on the security software
CO2	be able to apply the concepts machine learning based intrusion detection to analyze the IDSs.
CO3	be able to analyze the malware analysis and mitigation-based solutions for the probable threats therein.
CO4	be able to design the threat models based on machine learning approaches for network analysis.
CO5	be able to use the concepts of machine learning to prevent security design faults.

M.Tech. I (CSE) Semester – I	L	T	P	C
CSCS139: IDENTITY AND ACCESS MANAGEMENT (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	Understand fundamentals around identity, Authentication, Authorization and Access Control
2	Know various types of Access Controls and Access Administration at high level.
3	Student will get to learn how to access risk and its impact on access control.
4	Student will get the knowledge about Access Control Policies, Standards, Procedures.

INTRODUCTION	**(06 Hours)**
Understand the fundamentals of identity, Authentication & Authorization, Introduction to various types of Access Control & Access Administration, Risk Management and mitigation techniques.	
IDENTITY MANAGEMENT LIFE CYCLE	**(08 Hours)**
Identity Management, Digital Identities, Fundamental requirement for identity management, Identity Management Process, Authentication of Users, Authorization, Proofing, Provisioning, Maintenance, and Entitlement, Zero trust architecture	
AUTHENTICATOR MANAGEMENT (TOKENS, SINGLE SIGN-ON), OFFLINE AND DEVICE AUTHENTICATION	**(12 Hours)**
Token information, time-synchronized one-time passwords, mathematical-algorithm based one-time passwords, physical types, disconnected tokens, connected tokens, contactless tokens, Bluetooth and mobile device tokens, smart cards, types of smart card technology, smart card applications, multifactor authentication, dual control, continuous authentication, periodic authentication, time outs, reverse authentication, certificate-based authentication, authorization, access to systems vs. data, network, access control lists/matrix, and directories, SSO risks, SSO implementation: kerberos, Kerberos applications, Kerberos process, Kerberos considerations, Kerberos tools, network ports used during Kerberos authentication.	
ACCESS CONTROLS	**(15 Hours)**
Regulation of Access, Key concerns of Access Control, Mandatory Access Control (MAC), Non-Discretionary Access Control, Discretionary Access Control (DAC), Role-Based Access Control (RBAC), Rule – Based Access Control (RuBAC), Content Dependent, Context-Based, Temporal Isolation (Time Based), Attribute-Based, Separation of Duties, Security Architecture and Models, role hierarchies, constrained user interface (CUI), types of restricted interfaces, view-based access control (VBAC), and VBAC examples, Content-Dependent Access Control (CDAC), and Temperoal isolation (Time-Based) Access Control, Bell-LaPadula confidentiality Model, Biba integrity model, BLP and Biba model comparison, Clark-Wilson integrity model, and additional models, Applications of Access Control Models for IoT- Based Critical Infrastructure.	
ACCESS ADMINISTRATION PROCESS	**(04 Hours)**
Access provisioning, Access monitoring and review, Access termination	
Practical Assignments will be based on the coverage of above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**

(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

BOOKS RECOMMENDED

1. Peter O. Orondo, "Identity & Access Management: A Systems Engineering Approach", Createspace Independent Publisher.
2. Graham Williamson , Kent Spaulding , IlanSharoni , David Yip, Identity Management, MC Press.
3. Shiu-Kai Chin , Susan Beth Older, "Access Control, Security, and Trust: A Logical Approach", Chapman and Hall/CRC.
4. Dan M Bowers, "Access Control and Personal Identification Systems", Butterworth-Heinemann.
5. Osmanoglu, Ertem. "Identity and Access Management: Business Performance Through Connected Intelligence". Netherlands, Elsevier Science, 2013.

Course Outcomes **At the end of the course, students will**	
CO1	be able to understand the fundamentals of identity, Authentication & Authorization, Introduction to various types of Access Control & Access Administration.
CO2	be able to apply the authentication mechanisms to validate the digital identities.
CO3	be able to analyze the authenticator mechanisms and trust architectures.
CO4	be able to evaluate the access control models.
CO5	be able to design the access control models for IoT based applications.

M.Tech-I (CSE) Semester – I	L	T	P	C
CSCS141: SOFTWARE SECURITY (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objectives	
1	to discuss and explain the fundamental concepts of software security and defensive programming.
2	to enumerate the vulnerabilities in a typical memory unsafe language and the potential attacks/exploits.
3	to learn counter mechanisms for preventing the security vulnerabilities from being exploited and those for ensuring secure programs.
4	to analysethe limits of the applicability of the sast tools as well as the dast tools.
5	to design a program free from the known vulnerabilities as well as to withstand the zero-day vulnerabiliites.
6	to apply the skills learnt to generate secure programs.

INTRODUCTION	**(02 Hours)**
Introduction to the course. Review of Information Security concepts. The CIA Triad. Systems Security, Information Security, Application Security, Network Security – commonalities and differences. Essential Terminologies. Proactive software security vis-à-vis the security software. The concept of Software Security. Security in Software Development Life Cycle. Security as a Software Quality attribute. The trinity of troubles viz. Connectivity, Extensibility and Complexity. Studies of various catastrophes due to Insecure software. Model Based Security Engineering, Three Pillars of Software Security. Security in Software Lifecycle. The basic terminologies:a bug, an exploit, a threat, defects, vulnerabilities, risks, attacks.	
SECURITY ATTACKS AND TAXONOMY OF SECURITY ATTACKS	**(02 Hours)**
Review of security attacks – Taxonomy of Security Attacks, Methods. Attacks in each phase of software life cycle. Attacks on the TCP/IP protocol suite layers. Motivation for attackers, Methods for attacks: Malicious code, Hidden software mechanisms, Social Engineering attacks, Physical attacks. Non-malicious dangers to software. Attacks in each phase of software life cycle. Security Vulnerabilities and Attack Taxonomy in Internet of Things and Cyber Physical Systems. Review of Malwares: Viruses, Trojans, and Worms. Malware Terminology: Rootkits, Trapdoors, Botnets, Key loggers, Honeypots. IP Spoofing, Tear drop,DoS, DDoS attacks.	
THE SECURITY VULNERABILITIES-I	**(10 Hours)**
The Software Vulnerabilities: Vulnerabilities in the Memory-safe and memory-unsafe languages. Introduction to the Program Stack Analysis. Hands-on on Stack Analysis using gcc compiler and gdb debugger tool. Methods of security attack exploiting the vulnerabilities in the code. Taxonomy of security vulnerabilities. Remote Code Execution. State-of-the-art in research in Security Vulnerabilities.Overview of C, C++, Java Security Vulnerabilities. The common Web vulnerabilities:the Buffer Overflow - Stack overflows, Heap Overflows, the Code and Command Injections and the types: SQL injection, Cross-site scripting, Interpreter injection; the Format String vulnerabilities, writing shellcode. The Seven Pernicious Kingdoms. The Hidden form fields,Weak session cookies. Fault injection & Fault monitoring, Fail open authentication The OWASP Top 25 vulnerabilities in the current year.	
CODE REVIEWS AND STATIC ANALYSIS OF THE SOURCE CODE	**(08 Hours)**
Introduction to Code reviews and Static Informal reviews, Formal inspections. Illustrations.	

Introduction to Code reviews and Static Analysis. Code Reviews. Static Code Analysis. Static and Dynamic Application Security Testing (SAST and DAST) tools. Using basic linting to detect security vulnerabilities in the code with the linuxfind(), grep(), awk(), splint() and the FlawFinder. A glance at Code Analyzer Tools :Top-10: Raxis, SonarQube for Code Quality and Code Security, PVS-Studio, reshift, Embold, SmartBear Collaborator, CodeScene Behavioral Code Analysis, RIPS Technologies. Others: Cscope, Ctags, Editors, Cbrowser	
THE SECURITY VULNERABILITIES – II	**(09 Hours)**
Introduction to Session Management in Web Applications. Session Management best practices. The XSRF (Cross-site Request Forgery) Attack. Security vulnerabilities in Java: Connection String Injection, LDAP Injection, Reflected XSS, Resource Injection, Persistent XSS attacks in Java, The XPath Injection. Insecure deserialization, Remote code execution (RCE).Log injection.Mail injection.Vulnerabilities in Java libraries. Vulnerabilities in the Java sandboxing mechanism. Insufficient Transport Layer Protection (ITLP). Application misconfiguration and Software Composition Analysis (SCA).	
THREAT MODELLING	**(10 Hours)**
Finding Threats: Using STRIDE, Attack Patterns, Attack Trees, Misuse Patterns. Threat modelling with Attack Trees and Graphs. Anti-models. State transition diagrams. Access control models. Specifying Secrecy, Authentication and Assertions. Graph based specifications, UML-based specifications. Formal Security specifications. Web Threats, Cloud Threats, Mobile Threats, Threats to Cyrptosystems. Attack Libraries: Properties, OWASP Top Ten, CAPEC. Privacy Tools: Solove's Taxonomy of Privacy, Privacy Considerations for Internet Protocols, Privacy Impact Assessments (PIA), The Nymity Slider and the Privacy Ratchet, Contextual Integrity, LINDDUN. Threat Modelng tools: Whitebiards, Office-suites, Bug-tracking systems, TRIKE, Sea-monster, Elevation-of-privilege, ThreatModeler, Microsoft's SDL Threat Modeling Tool. When to Threat Model, What to model, Scenario-Specific Elements of Threat Modeling. Automated Threat Modeling, Threat modeling with code.	
DYNAMIC APPLICATION SECURITY TESTING	**(04 Hours)**
Basics, Approaches to DAST, DAST application analysis. DAST prerequisites. DAST job order, DAST run options. Tools, DAST Pros and Cons. DAST in DevOps practices. Interactive application security testing (IAST), Software composition analysis (SCA).	
Practical Assignments will be based on the coverage of above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

BOOKS RECOMMENDED

1. Michael Howard, David LeBlanc, “Writing Secure Code”, Microsoft Press, 2nd Edition. 2004.
2. McConnell Steve, “Code Complete (Developer Best Practices)”, Kindle Edition, Microsoft Press, 2nd Edition. 2004.
3. Edward Skoudis, Tom Liston, “Counter Hack Reloaded: A Step-by-Step Guide to Computer Attacks and Effective Defences”, Prentice Hall.
4. Mark G. Graff, Kenneth R.VanWyk, “Secure Coding: Principles and Practices”, O'Reilly Media.
5. Gary McGraw, “Software Security: Building Security In”, Addison-Wesley.

ADDITIONAL BOOKS RECOMMENDED

1. Stuart McClure, Joel Scambray, George Kurtz , “Hacking Exposed 7: Network Security Secrets & Solutions”, McGraw-Hill Osborne Media.

Course Outcomes At the end of the course, students will	
CO1	have a knowledge of the basic concepts and problems of memory unsafe and memory safe languages
CO2	be able to use the concepts to detect security vulnerabilities and prevent them.
CO3	be able to analyze/interpret program code for doing Static and Dynamic Security Testing.
CO4	be able to use the concepts of information security to prevent security design faults.
CO5	be able to design the new software with the security features builtin rather than reliance on the security software.

M. Tech-II (CSE) Semester – I	L	T	P	C
CSCS143: SECURITY AND PRIVACY IN RESOURCE CONSTRAINED ENVIRONMENTS (CORE ELECTIVE-1 OR 2)	3	0	2	4

Course Objectives	
1	To be able to UNDERSTAND the concept of resource-constrained devices, their characteristics, their applications and the constraints under which they operate.
2	To be able to UNDERSTAND the importance of the Security Issues in Embedded Devices/Systems, with Wireless Sensor Networks (WSNs) and the Internet of Things (IoT) as the case studies.
3	To be able to UNDERSTAND the Wireless Sensor Networks, the typical configurations of the constituent components viz. sensor motes, typical applications, operating environments, programming languages, simulators through demonstrations.
4	To be able to ANALYZE the security vulnerabilities with respect to various Denial of Service attacks at the Network Layer in WSNs as well as that in the Routing protocols for the MANETs.
5	To be able to ANALYZE the design of a typical link-layer security architecture for WSN and the design of the lightweight cyphers for the WSNs.
6.	To be able to DESIGN the security mechanisms suitable for WSNs viz. the IV, MAC, replay protection algorithm, key deployment algorithm for the hop-by-hop as well as end-to-end Secure Data Aggregation protocols.
7.	To be able to ANALYZE the advanced key management techniques viz. Attribute-Based Encryption, Identity Based Encryption, Function Encryption and their applications.

INTRODUCTION	(03 Hours)
Review of the Network Security Concerns. Fundamental Network Security Threats. Types of Network Security Threats. Network Security Vulnerabilities, their types: Technological Vulnerabilities, Configuration Vulnerabilities, Security policy Vulnerabilities. Types of Network Security Attacks.	
UBIQUITOUS AND PERVASIVE COMPUTING PARADIGM EMBEDDED SECURITY	**(06 Hours)**
Introduction to ubiquitous and pervasive computing paradigm, Embedded systems, Wireless Sensor Nodes as representative Embedded Systems, Wireless Sensor Networks (WSNs),Typical configurations, Typical Applications of the WSNs. Case studies of real world applications. Deployment models, Characteristics, Security Issues in Wireless Sensor Networks, Typical Attacks and Countermeasures.	
SECURE DATA AGGREGATION	**(12 Hours)**
The Concept of In-network processing and Data Aggregation. Motivation for the Link Layer Security architecture in Wireless Sensor Networks. Design Issues for Link Layer Security in Wireless Sensor Networks. Case studies of the hop-by-hop security architectures viz. TinySec, MiniSec, FlexiSec. Use of TOSSIM, Avrora or any other appropriate simulator. End-to-end security architecture for Wireless Sensor Networks.	
END-TO-END SECURE DATA AGGREGATION & ALGORITHMS	**(12 Hours)**
Use of Partial Homomorphic Encryption Algorithms – Case studies. Additive and Multiplicative Homomorphic Encryption algorithms. Robustness and Resilient Concealed Data Aggregation: Different approaches to offer data integrity viz. using conventional MAC - Aggregate MAC, Homomorphic MAC, Hybrid Secure Data Aggregation. Malleability Resilient Concealed Data Aggregation	
SECURITY OF THE ROUTING PROTOCOLS IN MANETS	**(02 Hours)**
Routing Protocols for MANETS, Their Security vulnerabilities, Typical Solutions. Security of the AODV protocol – typical mitigation to counter Black-hole attacks ON AODV.	
THE KEY MANAGEMENT IN THE EMBEDDED SYSTEMS	**(04 Hours)**

Public Key Infrastructure in Wireless Sensor Networks, The TinyPK protocol as a case study. Public Key Infrastructure in Wireless Sensor Networks, The Merkle-Hellman tree-based approach for key validation. Attribute Based Encryption and its motivation for Embedded Systems. Identity-based encryption and Functional encryption, motivation and case studies.	
THE TINY CIPHERS	**(02 Hours)**
Design of the STATE-OF-THE-ART tiny ciphers for the tiny devices and the RFID devices: TEA, XTEA, XXTEA, KTANTAN, mCrypton etc.	
THE INTERNET OF THINGS SECURITY	**(04 Hours)**
The Internet of Things. Architecture. Constituent Elements. The Security and Privacy Issues in IoT Systems. Overview of the IoT Protocols. Security of the RPL protocol. The IoT Security Protocols viz. ZigBee, Bluetooth, 6LowPAN, RPL. The CoAP.	
Practical Assignments will be based on the coverage of above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

BOOKS RECOMMENDED
1. The research papers prescribed in the class.

Course Outcomes: **At the end of the course, students will be able**	
CO1	to understand the concept of resource constrained devices, their characteristics, their applications and the constraints under which they operate.
CO2	to apply the security mechanism for resource constraints environments and identify the security vulnerabilities with respect to various Denial of Service attacks at the Network Layer in WSNs as well as that in the Routing protocols for the MANETs.
CO3	to analyze the design of a typical link layer security architecture for WSNs and the design of the light weight ciphers for the WSNs.
CO4	to evaluate the advanced key management techniques viz. Attribute Based Encryption, Identity Based Encryption, Function Encryption and their applications
CO5	to design the security mechanisms suitable for WSNs viz. the IV, MAC, replay protection algorithm, key deployment algorithm for the hop-by-hop as well as end-to-end Secure Data Aggregation protocols.

M.Tech. I (CSE) Semester – I	L	T	P	C
CSCS145: BLOCKCHAIN FUNDAMENTALS AND USE CASES (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objectives	
1	to demonstrate a familiarity with the concepts related to blockchain technology.
2	to apply the knowledge of cryptography and distributed systems to design decentralized applications.
2	to design and build smart contracts and distributed applications (DApps) for different applications.
3	to analyse and explore the real-world applications of blockchain technology.
4	to assess the strengths and weaknesses of blockchain enabled decentralization in different application scenarios.

INTRODUCTION	**(08 Hours)**
Introduction to Blockchain and Digital Currency, Evolution, Blockchain as Public ledger, Structure of a Block, Transactions, Merkel Trees, Peer-to-Peer Networks, Timestamp, Double Spend Problem, Decentralization Applications, Characteristics, Benefits and Challenges.	
CRYPTOGRAPHY IN BLOCKCHAIN	**(08 Hours)**
Hash Functions, Public Key Cryptosystem, Public Key Generation, Digital Signature, Zero-Knowledge Proof, k-Anonymity.	
SMART CONTRACTS AND CONSENSUS ALGORITHMS	**(05 Hours)**
Smart Contract, Applications of Smart Contracts, Mining, Hardness of Mining, Incentive, Consensus, Paxos, Consensus Algorithms - PBFT, PoW, PoS, etc.	
DISTRIBUTED COMPUTING IN BLOKCHAIN	**(07 Hours)**
Distributed System, Multi-Party Consensus Algorithm, Distributed Denial of Service (DDoS), Secure Multiparty Computation, Byzantine Generals Problem, Byzantine Fault Tolerance based and Leader-based Consensus Mechanism, CAP Theorem, Client-Server Model, Virtual Machines- Ethereum Virtual Machine (EVM) and Tron Virtual Machine (TVM), Quorum Systems, DApps.	
ETHEREUM AND HYPERLEDGER	**(07 Hours)**
Ethereum, Trustless ness and Immutability of Blockchain Technology, Proof of Work (PoW) and Proof of Stake (PoS), Ethereum Virtual Machine (EVM), Wallets for Ethereum, Solidity, Hyperledger, Corda, Hyperledger Fabric, Hyperledger Composer, Permissioned vs Permissionless Blockchain.	
BLOCKCHAIN FOR REAL-WORLD APPLICATIONS	**(06 Hours)**
Cryptocurrencies, Banking, Supply Chain, Healthcare, Real-Estate, Judiciary, IoT, Insurance, etc.	
ADVANCED TOPICS	**(04 Hours)**
Pool Mining, Sybil Attacks, Scalability of Blockchain, Smart Contract Vulnerabilities, Finalizing Transaction, Privacy Leakage. Note: topics Will Be Revised Time to Time According to Advancement and Trends in Technology.	
Practical Assignments will be based on the coverage of above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

BOOKS RECOMMENDED

1. Arvind Narayanan, Joseph Bonneau, Edward Felten, andrew Miller, Steven Goldfeder, “Bitcoin and Cryptocurrency Technologies: A Comprehensive introduction”, Princeton University Press, 2016.
2. Roger Wattenhofer, “Blockchain Science: Distributed Ledger Technology”, independently

	Published, ISBN-10 : 1793471738, 2019.
3.	Andreas M. Antonopoulos, “Mastering Bitcoin: Programming the Open Blockchain”, Shroff/O'Reilly, 2017.
4.	Elaine Shi, “Foundations of Distributed Consensus and Blockchains”, (URL: http://elaineshi.com/docs/blockchain-book.pdf), 2020.
5.	Alan T. Norman, “Blockchain Technology Explained: the Ultimate Beginner s Guide About Blockchain Wallet, Mining, Bitcoin, Ethereum, Litecoin, Zcash, Monero, Ripple, Dash, IOTA and Smart Contracts”, Amazon Digital Services, 2017.

ADDITIONAL BOOKS RECOMMENDED
1. Bahga, Arshdeep, and Vijay Madisetti. "Blockchain applications: a hands-on approach", VPT, 2017.

Course Outcomes **At the end of the course, students will**	
CO1	have knowledge about the design principles and challenges of blockchain and smart contracts.
CO2	be able to program and demonstrate the working of different consensus mechanisms.
CO3	be able to deploy and interact with blockchain systems by setting up a system and sending and reading the transactions.
CO4	be able to evaluate security, privacy, and efficiency of a given blockchain use case.
CO5	be able to design, build, and deploy distributed applications and smart contracts by identifying the need of blockchains to find the solution to the real-world problems.

M.Tech. I (CSE) Semester – I	**L**	**T**	**P**	**C**
CSCS147: NETWORK SECURITY (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objectives	
1	To understand basics of network security, computer and network security threats and basic paradigms and approaches used in network security at various layers.
2	To analyze existing authentication and key agreement protocols and to identify weaknesses of these protocols.
3	To acquire knowledge on standard algorithms used to provide confidentiality, integrity and authenticity.
4	To develop basic skills of secure network architecture and addressing network security issues, challenges and mechanisms.
5	To develop various security solutions against real life security threats.

INTRODUCTION	**(08 Hours)**
Model for Network Security, Network Security Threats, Attacks and Countermeasures, Importance of Effective Network Security Strategies, Overview of Cryptographic Primitives	
SECURITY AT THE APPLICATION LAYER	**(08 Hours)**
S/MIME-Functionality, Messages and Certificate Processing, Domain Keys Identified Mail, Pretty Good Privacy (PGP), GNU Privacy Guard (GPG)	
SECURITY AT THE TRANSPORT LAYER	**(07 Hours)**
SSL/TLS Architecture, Handshake Protocol, Change Cipher Spec Protocol, Alert Protocol, Record Protocol, SSL Message formats, Https, Secure Shell (SSH).	
SECURITY AT THE NETWORK LAYER	**(07 Hours)**
IP Security Overview, IP Security Policy, Encapsulating Security Payload, internet Key Exchange, Authentication Header.	
WIRELESS NETWORK SECURITY	**(07 Hours)**
Wireless Security, Mobile Device Security, IEEE 802.11i Wireless LAN Security, WEP and WPA Protocols.	
NETWORK ACCESS CONTROL AND CLOUD SECURITY	**(08 Hours)**
Network Access Control, Extensible Authentication Protocol, IEEE 802.1x Port-Based Network Access Control, Cloud Computing, Cloud Security Risks and Countermeasures, Data Protection in the Cloud, Cloud Security as a Service, Addressing Cloud Computing Security Concerns.	
Practical Assignments will be based on the coverage of above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

BOOKS RECOMMENDED

1. William Stallings, "Network Security Essentials: Applications and Standards", Fourth Edition, 2011.
2. Charlie Kaufman, Radia Perlman, Mike Speciner, "Network Security: Private Communication in a Public World", 2nd Ed., Prentice Hall PT, 2002.

3. William Stallings, "Cryptography and Network Security: Principles and Practice", 7th Ed. Pearson, 2017.
4. Behrouz forouzan, Debdeep Mukhopadhyay, "Cryptography and Network Security", 2nd Ed., Tata McGraw-Hill Education. 2010.
5. Chris McNab, "Network Security Assessment". 3rd Ed., O'Reilly Media, 2004.

Course Outcomes **At the end of the course, students will**	
CO1	be able to assess vulnerability and weaknesses in the network.
CO2	be able to understand network security techniques to protect against threats in the network.
CO3	be able to analyze different network security techniques to identify, classify the network security threats and select suitable for the given application scenario.
CO4	be able to set up firewall and intrusion detection system for organization's security and evaluate possible threats and attacks at various layers of TCP/IP suite.
CO5	be able to design robust and efficient system for network security for organizations.

M.Tech. I (CSE) Semester – I	L	T	P	C
CSCS149: MODERN CRYPTOGRAPHY (CORE ELECTIVE-1 OR 2)	**3**	**1**	**0**	**4**

Course Objectives	
1	to discuss the importance of group theory, number theory, and discrete probability with respect to the modern cryptography.
2	to demonstrate the requirements and applications of deterministic and probabilistic algorithms.
3	to develop the ability to model security problems and to write security proofs.
4	to describe fundamental cryptographic primitives including Key Exchange, Digital Signatures, Oblivious Transfer, Public-Key Encryption, Commitment, to evaluate the security in different real-world scenarios.
5	to communicate different computational problems that are important for cryptography such as the factoring problem, the RSA problem, the discrete-logarithm problem.

INTRODUCTION	**(04 Hours)**
Classical Cryptography and Modern Cryptography, Principles of Modern Cryptography, formal Definitions, Precise Assumptions, Proofs of Security, Provable Security and Real-World Security.	
PERFECTLY SECRET ENCRYPTION	**(04 Hours)**
Formal Definitions, Shannon’s Theory, one-Time Pad, Limitations of Perfect Secrecy.	
PRIVATE-KEY ENCRYPTION	**(06 Hours)**
Defining Computationally Secure Encryption, Semantic Security, Constructing Secure Encryption Schemes-Pseudorandom Generators and Stream Ciphers, Proofs by Reduction, Cryptanalytic Attacks-Chosen-Plaintext Attacks and CPA-Security, Constructing CPA-Secure Encryption Schemes, Pseudorandom Functions and Block Ciphers, CPA-Secure Encryption From Pseudorandom Functions, Chosen-Ciphertext Attacks- Defining CCA-Security.	
HASH FUNCTIONS AND APPLICATIONS	**(05 Hours)**
Hash Functions-one-Wayness and Collision Resistance, Merkle–Damgard Construction, Attacks on Hash Functions-Birthday Attacks, Random-oracle Model, Merkle Trees.	
MESSAGE AUTHENTICATION CODES	**(06 Hours)**
Message Authentication Codes – formal Definitions, Design, and Proof of Security, HMAC, CBC-MAC, Authenticated Encryption, information-Theoretic Macs, Limitations on information-Theoretic Macs	
ALGORITHMS FOR FACTORING AND COMPUTING DISCRETE LOGARITHMS	**(06 Hours)**
Algorithms for Factoring-Pollard’s P − 1 Algorithm, Pollard’s Rho Algorithm, Quadratic Sieve Algorithm, Algorithms for Computing Discrete Logarithms- Pohlig–Hellman Algorithm, Baby-Step/Giant-Step Algorithm, Discrete Logarithms From Collisions, index Calculus Algorithm.	
PUBLIC-KEY ENCRYPTION	**(06 Hours)**
RSA Encryption, Security Against Chosen-Plaintext Attacks, Security Against Chosen-Ciphertext Attacks, RSA Implementation Issues and Pitfalls, Computational Diffie-Hellman/Decisional Diffie-Hellman Based Encryption, Elliptic Curve Cryptography-Elliptic Curve Over Finite Fields and Binary Fields, Point Addition Operation, Elliptic Curve Discrete Logarithm Problem, Cryptosystems Based on Elliptic Curve.	
ADVANCED TOPICS	**(08 Hours)**

Zero-Knowledge Proofs, Secret Sharing Schemes, Lattices and Cryptography, and Topics related to Modern Cryptography	
Tutorial Assignments Will Be Based on the Coverage of Above topics.	**(15 Hours)**
(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

BOOKS RECOMMENDED

1. Katz & Lindell, introduction to Modern Cryptography: Principles and Protocols, Second Edition, Publisher: Chapman & Hall/CRC, 2014.
2. Douglas R. Stinson, Cryptography: Theory and Practice, Third Edition, Publisher: Chapman and Hall/CRC, 2005.
3. Goldreich, Foundations of Cryptography, Cambridge University Press, 2005 (Volume 1 and 2).
4. William Stallings, “Cryptography and Network Security: Principles and Practice”, 7th Ed. Pearson, 2017.
5. Katz, Jonathan, and Lindell, Yehuda, “ Introduction to Modern Cryptography”. United States, CRC Press, 2020.

Course Outcomes
At the end of the course, students will be able to

CO1	communicate formal security definitions, security assumptions and security proofs of modern cryptosystems.
CO2	differentiate various deterministic and probabilistic algorithms and understand their applicability in real-world application scenarios.
CO3	present the security models and security proofs of well-known algorithms.
CO4	demonstrate familiarity with fundamental cryptographic primitives and apply the knowledge to various application domains.
CO5	compare number theoretic problems used by cryptographic algorithms and evaluate their respective strengths and weaknesses.

M.Tech. I (CSE) Semester – I	L	T	P	C
CSCS151: INFORMATION RETRIEVAL (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	To know the concepts of data retrieval system, introduces the basic principles of data storage, processing, and retrieval in terms of the data retrieval system analysis and design.
2	To understand how information is processed within a data retrieval system.
3	To compare and contrast data retrieval models and internal mechanisms.
4	To critically evaluate data retrieval system effectiveness and improvement techniques.
5	To understand the unique features of Internet-based information retrieval.

INTRODUCTION	**(04 Hours)**
Goals and history of Data Retrieval, Significance of Information Retrieval, Impact of the web on Data Retrieval, Applications of Data Retrieval, Basic Data Retrieval System Architecture, Information Retrieval, Relationships between Digital library and IRS, Abstraction, Algorithms, Data Structures, Measure of information systems, Logical Organization, Physical Organization, Components of Information Retrieval Systems, Comparisons among Different Information Systems.	
DATA CONTROL, PRESENTATION AND RETRIEVAL MODELS	**(06 Hours)**
Query, Differences between Documents and Queries, Type of Documents, Document Surrogates, Vocabulary Control, Structure of a Thesaurus, Structural Representation, Overview of Retrieval Models, Probabilistic Models, Ranking based on Language Models, Complex Queries and Combining Evidence, Machine Learning and Data Retrieval, Application-Based Models, Vector Model, Document-term Matrix, Methods for Designing Weights to Terms, Query in the Vector Model, Spatial Representation of a Document in Vector Model, Similarity between a Query and a Document.	
BASIC SEARCHING AND INDEXING	**(06 Hours)**
Simple Tokenizing, Stop-word Removal, Stemming and Lemmatization, Inverted Indices and Files, Sparse Vectors, Positional Postings and Phrase Queries, Spelling Correction, Phonetic Correction, Index Construction, Index Compression, Extracting Index Terms.	
SIMILARITY MEASURE AND AUTOMATIC CLUSTERING APPROACHES	**(05 Hours)**
Data Fusion, Term Association, General Similarity Measures, Similarity Measures in the Vector Retrieval Model, Extended User Profile, Clustering, Classification, Significance of a Clustering Approach in IR, Categorization of Clustering Algorithms, Non-hierarchical Clustering Algorithm, K-means Clustering algorithm, K-means in SPSS, Hierarchical Clustering Algorithm, Hierarchy Cluster in SPSS	
INFORMATION VISUALIZATION	**(06 Hours)**
Visualization Systems, VIBE, DARE, Visual Thesaurus, Inxight, Reveal Things, Tilebars, SQWID, JAIR INFORMATION SPACE, WebMap, Excentric Labeling, Tree Map, LifeLines, Web Brain, NiF Elastic Catalog, Dynamic Diagrams, Health InfoPark.	
EVALUATION IN DATA RETRIEVAL	**(06 Hours)**
Data Retrieval System Evaluation, Standard test Collections, Evaluation of Unranked Retrieval Sets, Evaluation of Ranked Retrieval Results, Assessing Relevance, A Broader Perspective: System Quality and User Utility, Kappa Measure, Grandfield Experimental Study, Evaluations on Benchmark Text Collections, Web Mining, Web Retrieval Model.	
RELEVANCE FEEDBACK AND QUERY EXPANSION	**(06 Hours)**
Framework for Feedback Methods, Explicit Relevance Feedback, Explicit Feedback Through Clicks, Implicit Feedback Through Local Analysis, Implicit Feedback Through Global Analysis, Trends and Research Issues, Recommender systems.	

IMAGE AND INTERNET DATA RETRIEVAL	**(06 Hours)**
Content-based Image Retrieval, Image Feature Description, Order system, Texture, Shape, Characteristics of Image Queries, Image Retrieval systems, Challenge in the Web, Language Distribution, Centralized Architecture, Crawlers, Jargons, Breadth First Approach, Depth First Approach, Crawling Approach, Web Page Ranking, Meta-search, Considerations for Meta-search Engines.	
Practical and mini-projects will be based on the coverage of the above topics.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

List of Practical (Problem statements will be changed every year and will be notified on the website.)	
1	Experiments using different platforms for handling the data of different volumes.
2	Experiments for implementing distributed systems for data storage and its retrieval.
3	Experiments of accessing Big-data and developing an exemplary application.
4	Implementation of mini projects in different fields like image processing, web services, natural language processing, information security etc.
5	Comparison and analysis of different retrieval techniques.

BOOKS RECOMMENDED

1. Christopher D. Manning, Prabhakar Raghavan, and Hinrich Schütze, "Introduction to Information Retrieval", Cambridge University Press.
2. Ricardo Baeza-Yates and Berthier Ribeiro-Neto, "Modern Information Retrieval", Addition Wesley.
3. Bing Liu, "Web Data Mining", Springer.
4. Manning D. Christopher, Prabhakar Raghavan, Schütze Hinrich, "Introduction to Information Retrieval", Cambridge University Press.
5. Stefan Buettcher, Charles L. A. Clarke, Gordon V. Cormack, "Information Retrieval: Implementing and Evaluating Search Engines", The MIT Press.

ADDITIONAL BOOKS RECOMMENDED

1. Richard K. Belew, "Finding out about--A cognitive perspective on search engine technology and the www", Cambridge University Press.
2. Soumen Chakrabarti, "Mining the Web", Morgan-Kaufmann Publishers.
3. David A. Grossman and Ophir Frieder, "Information Retrieval: Algorithm and Heuristics", Springer.

Course Outcomes **At the end of the course, students will**	
CO1	have knowledge to describe current trends in information retrieval such as information visualization and be familiar with the structure of queries and documents.
CO2	be able to implement techniques for data retrieval systems.
CO3	be able to analyze the different Retrieval Models.
CO4	be able to evaluate the retrieved information based on various parameters.
CO5	be able to design efficient and robust data retrieval for real time applications.

M. Tech. I (CSE) Semester – I	**L**	**T**	**P**	**C**
CSCS153: BIG DATA ANALYTICS AND LARGE-SCALE COMPUTING (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	To learn the basics of big data, its characteristics, big data management issues, processing and applications with the help of big data platforms and storage models for big data management.
2	To learn the management and analysis of big data using technology like Hadoop, NoSql, MapReduce, PIG & HIVE.
3	To apply the data mining algorithms on big data for scalability of the real time applications.
4	To develop research interest towards advances in data mining by analyzing the available approaches with the help of evaluating parameters.
5	To build big data analytics and management systems with visualization using the latest technology to solve real problems.

INTRODUCTION	**(05 Hours)**
Definition of Big Data, Source of Big Data, Convergence of Key Trends, Unstructured Data, Industry Examples of Big Data, Web Analytics, Fraud and Risk Associated with Big Data, Credit Risk Management, Big Data in Algorithmic Trading, Healthcare, Medicine, Marketing and Advertising, Big Data Technologies, Introduction to Hadoop and Spark, Open Source Technologies, Cloud, Mobile Business Intelligence, Crowd Sourcing Analytics, Inter and Trans Firewall Analytics.	
BIG DATA ANALYTICS	**(06 Hours)**
Big Data Processing: Batch Data Processing and Stream Data Processing, Computing Environments for Big Data Analytics, Implementation of Batch and Real Time Event Processing: Integration of Disparate Data Stores/Data Lake, Mapping Data to the Programming Framework, Connecting and Extracting Data from Storage, Transforming Data for Processing, Querying.	
DISTRIBUTED FILE SYSTEM HADOOP	**(08 Hours)**
Introduction, HDFS Daemons, Different Methods to HDFS Access, Hadoop, Features, Google File System Features, Phases involved in Map Reduce, Architecture, Execution of MapReduce Jobs, Monitoring the progress of job flows, Building Blocks of Hadoop MapReduce. Data format, Analyzing data with Hadoop, Scaling Out, Hadoop Streaming, Hadoop Pipes, Design of Hadoop Distributed File System, MapReduce, HDFS Concepts: Java Interface, Data Flow, Hadoop I/O, Data integrity, Compression, Serialization, Avro, File-based Data Structures, Mahout, Pig, Hive, HBase.	
DISTRIBUTED MACHINE LEARNING	**(08 Hours)**
Review of Machine Learning: Supervised and Unsupervised Learning, Linear algebra; Classification Formulation, Closed Form Solution, Computational Complexity, Grid Search, Computation Storage Communication, Probabilistic Prediction, Backpropagation Graph and Compute Gradients for Model Training, Automatic Differentiation Graph-Level Optimization Parallelization/Distributed Training Data Layout and Distributed Linear Regression and Distributed Logistic Regression, Placement Kernel Optimizations, Memory Optimizations, Distributed Principal Component Analysis, Regularization and Optimization for Training Deep Neural Networks, Sequence Modeling, Federated Learning.	
BIG DATA ANALYSIS WITH MLLIB, SPARKSQL AND GRAPHX	**(06 Hours)**
HBase, Data Model and Implementations, HBase Clients, HBase Examples, Praxis, Cassandra, Cassandra data Model, Cassandra Examples, Cassandra Clients, Hadoop Integration, Hive, Data Types and File Formats, HiveQL Data Definition, HiveQL Data Manipulation, HiveQL Queries, Applications on Big Data Using Pig and Hive, Data Processing Operators in Pig, Fundamentals of ZooKeeper, K-Means Clustering,	

Decision Trees, Random Forests, Recommenders, Table in Spark, Higher Level Declarative Programming, Network Structure, Computing Graph Statistics.	
BIG DATA STORAGE MODELS	**(06 Hours)**
Introduction, NoSQL Databases, Need, Types, Comparison with RDBMS, Architecture and Features of NoSQL Databases: Distributed Hash-table, Key-Value Storage Model, Document Storage Model, Graph Storage Models, Lambda Architecture, Data Ingestion, Design and Provision Compute Resources, Storage Technology, Streaming Units, Configuration of Clusters for Latency and Throughput, Output Visualization.	
SCALABLE ALGORITHMS	**(06 Hours)**
Mining Big Data, Centrality, Similarity, Al-Distances Sketches, Community Detection, Link Analysis, Spectral Techniques, MapReduce, Pig Latin, and NoSQL, Algorithms for Detecting Similar Items, Recommendation Systems, Data Stream Analysis Algorithms, Detecting Frequent Items, Data Ingestion, Storage of Data, Data Transfer, Compute Clusters and Configuration of Design.	
Practical Assignments will be based on the coverage of above topics.	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

List of Practical (Problem statements will be changed every year and will be notified on the website.)	
1	Working with various functions of Hadoop MapReduce.
2	Working with pySpark and RDDs.
3	Regression and classification in Spark.
4	Data analysis with PCA in Spark.
5	Hands-on with MLlib and SparkSQL.
6	Use cases and implementation for Big data management and large scale machine learning algorithms.

BOOKS RECOMMENDED

1. Ron Bekkerman, Mikhail Bilenko, John Langford, “Scaling up Machine Learning: Parallel and Distributed Approaches”, Cambridge University Press.
2. Michael Minelli, Michele Chambers, AmbigaDhiraj, “Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley.
3. Michael Berthold, David J. Hand, “Intelligent Data Analysis”, Springer.
4. Tom White, “Hadoop: The Definitive Guide”, O’reilly Media.
5. ArshdeepBahga, Vijay Madisetti, “Big Data Science & Analytics: A Hands on Approach “, VPT.

ADDITIONAL BOOKS RECOMMENDED

1. Edward Capriolo, Dean Wampler, and Jason Rutherglen, “Programming Hive”, O'Reilly.
2. Lars George, “HBase: The Definitive Guide”, O'Reilly.
3. Eben Hewitt, “Cassandra: The Definitive Guide”, O'Reilly.
4. Alan Gates, “Programming Pig”, O'Reilly.
5. Sandy Ryza, Uri Laserson, Sean Owen, Josh Wills, “Advanced Analytics with Spark”, O'Reilly.
6. Holden Karau, Andy Konwinski, Patrick Wendell, and MateiZaharia,Learning Spark, O'Reilly.
7. Jure Leskovec, Stanford Univ.AnandRajaraman, Milliway Labs, Jeffrey D. Ullman, “Mining of Massive Datasets”, Cambridge University Press.
8. Ron Bekkerman, Mikhail Bilenko and John Langford, “Scaling up Machine Learning: Parallel and Distributed Approaches”, Cambridge University Press.
9. Arvind Sathi, “Big Data Analytics: Disruptive Technologies for Changing the Game”, MC Press.
10. Tom Plunkett, Brian Macdonald et al, “Oracle Big Data Handbook”, Oracle Press.
11. Jay Liebowitz, “Big Data and Business analytics”, CRC press.

Course Outcomes At the end of the course, students will	
CO1	have knowledge of the key issues in big data management and its associated applications in intelligent business and scientific computing.
CO2	be able to apply theoretical foundations of mining algorithms for the usage applicability of business, engineering and scientific problems for big data processing and scalability.
CO3	be able to analyze Hadoop related tools such as HBase, Cassandra, and Hive for big data analytics.
CO4	be able to evaluate the big data analytics applications and evaluation measures to have a productive solution.
CO5	be able to build a complete business data analytics solution for any real time problem.

M.Tech. I (CSE) Semester – II	L	T	P	C
CSCS112: ANN AND DEEP LEARNING (CORE ELECTIVE 3 OR 4)	**3**	**0**	**2**	**4**

Course Objective	
1	To introduce the fundamental techniques and principles of Neural Networks
2	To study the different models in ANN and their applications.
3	To explore in depth deep neural architectures for learning and inference and to evaluate the performance of neural architectures in comparison to other machine learning methods
4	To familiarize deep learning concepts with Convolutional Neural Network case studies
5	To implement the concepts of deep learning algorithms and solve real-world problems.

INTRODUCTION TO ARTIFICIAL NEURAL NETWORKS	**(05 Hours)**
Fundamentals of Neural Networks, Computational models of neurons, Structure of neural networks, Single and multi-layer perceptrons, Learning Methods, Functional units of ANN for pattern recognition tasks, Applications.	
FEEDFORWARD NEURAL NETWORKS	**(06 Hours)**
Pattern classification using perceptron, Multilayer feedforward neural networks, Training Neural Network: Empirical risk minimization, Activation functions, Loss functions, Back propagation learning, Regularization, Model selection and optimization, Auto encoders.	
DEEP NEURAL NETWORKS	**(12 Hours)**
Deep Feed Forward network, Difficulty of training DNNs, Greedy layer wise training, Optimization for training DNNs, Newer optimization methods for neural networks (AdaGrad, RMSProp, Adam), Second order methods for training, Regularization methods: dropout, drop connect, batch normalization.	
CONVOLUTION NEURAL NETWORKS	**(12 Hours)**
Introduction to CNNs – convolution, pooling, Deep CNNs, Different deep CNN architectures – LeNet, AlexNet, VGGNet, GoogLeNet, ResNet. Training CNNs: weights initialization, batch normalization, hyper parameter optimization, Understanding and visualizing CNNs, Applications of CNN– Object Detection, and Content based image Retrieval.	
RECURRENT NEURAL NETWORKS	**(06 Hours)**
Sequence modeling using RNNs, Back propagation through time, Long Short-Term Memory, Bidirectional LSTMs, Bidirectional RNNs, Gated RNN Architecture, Basics of word embedding.	
APPLICATIONS AND TOOLS	**(04 Hours)**
Applications in vision, speech and natural language processing e.g., Image and video captioning along with the use of attention. Deep Learning Tools: Caffe, Theano, Torch.	
Practical Assignments will be based on the coverage of above topics.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

List of Practical (Problem Statements will be changed every year and will be notified on Website.)	
1	Practical based on single layer and multi-layer feed forward Neural Network.
2	Practical based on different activation functions and loss functions.

3	Practical based on back propagation learning algorithm.
4	Implement trained CNN architectures.
5	Implement object detection task using trained CNN models.
6	Practical based on word embedding.
7	Practical based on LSTM.
8	Practical based on GRU.

BOOKS RECOMMENDED

1. S. Haykin, "Neural Networks and Learning Machines" , Prentice Hall of India, 2010.
2. Ian Goodfellow, YoshuaBengio and Aaron Courville, "Deep learning", In preparation for MIT Press, 2016.
3. CharuC.Aggarwal "Neural Networks and Deep learning" Springer International Publishing, 2018.
4. Satish Kumar, "Neural Networks - A Class Room Approach", Second Edition, Tata McGraw-Hill, 2013.
5. Simon Haykin, "Neural Networks, A Comprehensive Foundation", 2nd Edition, Addison Wesley Longman, 2001.

ADDITIONAL BOOKS RECOMMENDED

1. 1.B. Yegnanarayana, "Artificial Neural Networks", Prentice- Hall of India, 1999.
2. 2.Bishop, Christopher M. "Pattern Recognition and Machine Learning". Springer, 2006.
3. 3.Duda R.O., Hart P.E., Stork D.G., "Pattern Classification", Second edition, Wiley-Interscience, 2001.
4. 4.Russell S., Norvig N., "Artificial Intelligence: A Modern Approach", Prentice Hall Series in Artificial Intelligence, 2003.

Course Outcomes **At the end of the course, students will**	
CO1	be able to understand basic Neural Network architectures, key concepts, issues and practices, core algorithms and optimization when training and modeling with deep architectures.
CO2	be able to apply fundamental principles, theory and approaches for learning with deep neural networks.
CO3	be able to analyze main variants of deep learning architectures, their typical applications.
CO4	be able to evaluate the performance of a different Convolution Neural Networks, LSTM and Gated RNN Architecture
CO5	be able to design real world application based on the concepts of ANN and deep learning.

M.Tech. I (CSE) Semester – II	L	T	P	C
CSCS114: INTRODUCTION TO FORMAL SPECIFICATION AND VERIFICATION (CORE ELECTIVE 3 OR 4)	**3**	**0**	**2**	**4**

Course Objective	
1	To understand the general concepts of requirements extraction, modelling and specifications.
2	To design the requirements model and specify the requirements using semi-formal techniques viz. Finite State Machines, Communicating Finite State Machines, and Petrinets.
3	To understand the basic concepts in logic specifications and in temporal logic, set theory, and discrete math.
4	To specify the systems using logic specifications and using the Temporal Logic of Actions (TLA+).
5	To verify general safety properties by proofs or TLC model checking tool.
6	To understandsystemcorrectnessasanimportantpartofengineeringethics.

INTRODUCTION	**(02 Hours)**
Functional & Non-functional requirements. Software Qualities the non-functional requirements. Software Requirements Extraction, Modeling and Specifications.	
SOFTWARE VARIFICATION AND VALIDATION	**(07 Hours)**
Approaches to analyse software code. Execution-based and non-execution-based testing. Static analysis. Static analysis using the illustrative tools viz.Splint, FlawFinder, SonarQube, Synopsis's Coverity Scan OR any other static analysis tool. Detection of software vulnerabilities using the gdband Stack analysis.	
SOFTWARE SPECIFICATIONS	**(08 Hours)**
Formal Specifications. Specification definition, types and the uses. Qualities of the Specifications and illustrations of bad specifications. Formal Methods for Verification of Specifications: Semi-Formal Specification techniques viz. Finite State Machines, The Communicating Finite State Machines, Petri nets, Timed Petri nets. Modeling the classical distributed/-concurrent applications viz. the Producer Consumer problem, the Readers Writers problem, the Traffic Lights problem, the Trains tracks shunting problem, the Coffee-Biscuits-Chocolates vending machine problem, the Elevator Controller problem etc. Extending the basic Petrinets.	
MODELLING AND FORMAL VERIFICATION OF DISTRIBUTED APPLICATIONS	**(08 Hours)**
Illustrating the basic theory of Formal Verification. Illustrating modeling with PROMELA through various examples. Modelling distributed applications using Petrinet modeling tool. Specifications using the Alloy, with the Alloy tutorial.	
DECLARATIVE SPECIFICATIONS	**(08 Hours)**
Review of the Propositional Logic and the First Order logic, Inference Rules. Logic specifications, Specifying programs and parts of programs. Specifying Classes and non-terminating behaviours. Logic Specifications case study through the Elevator Controller Problem. Descriptive Specifications, Algebraic specifications and illustrations. Specifications for ADTs like String, Queue, Editors, etc.	
FORMAL SPECIFICATION AND VERIFICATION LANGUAGE	**(12 Hours)**
Temporal Logic of Actions (TLA+). Simple math and TLA specifications. Asynchronous interface specification and TLATeX type setter. Caching memory specifications. Temporal logic: safety and liveness properties TLA+ for program designing, modeling, documentation, and verification. Applications for concurrent systems and distributed systems. Specification and verification of real	

time systems.	
Practical assignments will be based on the coverage of the above topics.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

BOOKS RECOMMENDED

1. L. Lamport, Specifying Systems: The TLA+ Language and Tools for Hardware and Software Engineers. Addison Wesley. 2003. Ghezzi, Jazayeri, Mandrioli: Fundamentals of Software Engg, 2003 ed, Pearson EDU
2. Pankaj Jalote: An integrated approach to SE, Narosa, 3rd edition, '05
3. Rajib Mall: Software Engineering, Prentice Hall of India, 4th Edition, 2014.
4. Grumberg, Clarke, Peled: Model Checking, The MIT Press, 2001.
5. Gerard J. Holzmann. Design and Validation Of Computer Protocols (Prentice Hall Software Series). October 1990

Course Outcomes
At the end of the course, students will

CO1	Understand the general concepts of requirements extraction, modeling and specifications.
CO2	be able to specify the systems using logic specifications and using the Temporal Logic of Actions (TLA+).
CO3	Understand the basic concepts in logic specifications and in temporal logic, set theory, and discrete math.
CO4	be able to verify general safety properties by proofs or TLC model checking tool.
CO5	be able to design the requirements model and specify the requirements using semi-formal techniques and using SPIN/PROMELA.

M.Tech. I (CSE) Semester – II	**L**	**T**	**P**	**C**
CSCS116: NATURAL LANGUAGE PROCESSING (CORE ELECTIVE 3 OR 4)	**3**	**0**	**2**	**4**

Course Objective	
1	To comprehend natural language processing in order to extract information.
2	To understand information about language-specific tasks and learning models.
3	To investigate the use of artificial intelligence to comprehend the semantics of text data.
4	To know about text processing at syntactic, semantic, and pragmatic levels.
5	To understand data extraction from unstructured text by identifying references to named entities as well as stated relationships between such entities.

INTRODUCTION AND LANGUAGE MODELING	**(12 Hours)**
Introduction to Computational Linguistics, Word Meaning, Distributional Semantics, Word Sense Disambiguation, Sequence Models, N-gram Language Models, Feed forward Neural Language Models, Word Embedding, Recurrent Neural Language Models, Tokenization, Lemmatization, Stemming, Sentence Segmentation, POS Tagging and Sequence Labeling, Structured Perceptron, Viterbi – Loss, Augmented Structured Prediction, Neural Text Models and Tasks.	
INFORMATION EXTRACTION	**(11 Hours)**
Information Extraction from Text, Sequential Labeling, Named Entity Recognition, Semantic Lexicon Induction, Relation Extraction, Paraphrases Inference Rules, Summarization, Event Extraction, Opinion Extraction, Temporal Information Extraction, Open Information Extraction, Knowledge based Population, Narrative Event Chains and Script Learning, Knowledge Graph Augmented Neural Networks for Natural Language.	
MACHINE TRANSLATION AND ENCODER-DECODER MODELS	**(11 Hours)**
Machine Translation, Encoder-Decoder Models, Beam Search, Attention Models, Multilingual Models, Syntax, Trees, Parsing, Transition based Dependency Parsing, Graph based Dependency Parsing, Transfer Learning, Deep Generative Models for Natural Language Data, Text Analytics, Text Mining, Information Extraction with AQL-Conversational AI.	
APPLICATION AND CASE STUDIES	**(11 Hours)**
Application: Spelling Correction, Sentiment Analysis, Word Sense Disambiguation, Text Classification, Machine Translation, Question Answering System, Intent Detection, False Fact Detection.	
Practical assignments will be based on the coverage of the above topics	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

List of Practical (Problem statements will be changed every year and will be notified on the website.)	
1	Create an application in Python with the NLTK library to tokenize the words present in a paragraph.
2	Perform tasks with NLTK (Natural Language Toolkit).
3	Tasks to be Performed in SpacCy Library.
4	Practicals based on huggingface library.
5	Text Classification using movie reviews database, etc.
6	Practical implementation of application and case study.

BOOKS RECOMMENDED
1. Emily Bender, "Linguistics Fundamentals for NLP", Morgan Claypool Publishers. 2. Jacob Eisenstein, "Natural Language Processing", The MIT Press. 3. Dan Jurafsky, James H. Martin, "Speech and Language Processing", Prentice Hall. 4. Chris Manning, HinrichSchutze, "Foundations of Statistical Natural Language Processing", The MIT Press. 5. Pushpak Bhattacharyya, "Machine Translation", CRC Press.

Course Outcomes **At the end of the course, students will**	
CO1	be able to understand how language works, including the word structure, sentence structure, and meaning.
CO2	be able to learn how to reframe NLP problems as learning and inference tasks, as well as how to deal with the associated computational challenges
CO3	be able to use text processing at the syntactic, semantic, and pragmatic levels.
CO4	be able to learn about text mining and manipulation techniques.
CO5	be able to retrieve information from the text and can use it for decision making.

M.Tech. I (CSE) Semester – II	**L**	**T**	**P**	**C**
CSCS118: REINFORCEMENT LEARNING (CORE ELECTIVE 3 OR 4)	**3**	**0**	**2**	**4**

Course Objective	
1	To learn reinforcement learning as a general framework to design an autonomous decision-making system.
2	To learn how to define RL tasks and the core principals behind the RL, including policies, value functions, deriving Bellman equations.
3	To understand and work with tabular methods to solve classical control problems.
4	To recognize current advanced techniques and applications in RL.
5	To describe (list and define) multiple criteria for analyzing RL algorithms and evaluate algorithms on these metrics: e.g. regret, sample complexity, computational complexity, empirical performance, convergence, etc.

INTRODUCTIONS	**(06 Hours)**
Introduction to Reinforcement Learning, Basics of RL, Defining RL Framework and Markov Decision Process, Polices, Value Functions and Bellman Equations, Exploration vs. Exploitation, Code Standards and Libraries used in RL (Python/Keras/Tensorflow).	
TABULAR METHODS AND Q-NETWORKS	**(08 Hours)**
Planning through the use of Dynamic Programming and Monte Carlo, Tabular MDP planning, Temporal-Difference Learning Methods (TD(0), SARSA, Q-Learning), n-step Bootstrapping, Deep Q-Networks (DQN, DDQN, Dueling DQN, Prioritized Experience Replay), Tabular RL Policy Evaluation.	
FUNCTION APPROXIMATIONS	**(07 Hours)**
Introduction to Function Approximations, Function Approximation with on-policy methods, Non-linear Function Approximation, Function Approximation with off-policy methods, Average Reward RL.	
POLICY GRADIENTS METHODS	**(08 Hours)**
Introduction to Policy-based Methods, Vanilla Policy Gradient, REINFORCE Algorithm and Stochastic Policy Search, Actor-critic Methods (A2C, A3C), Advanced Policy Gradient (PPO, TRPO, DDPG).	
PLANNING AND MODEL-BASED RL	**(08 Hours)**
Model based RL approach, Model Predictive Control, Eligibility Traces, Hierarchical RL, Partial Observability, POMDPs, and Offline RL.	
RECENT ADVANCES AND APPLICATIONS	**(08 Hours)**
Meta-learning, Multi-Agent Reinforcement Learning, Partially Observable Markov Decision Process, Ethics in RL, Applying RL for Real-World Problems.	
Practical will be based on the coverage of the above topics separately.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

List of Practical (Problem Statements will be changed every year and will be notified on Website.)	
1	Implementation of RL Framework and Markov Decision Process Model.
2	Implementation of Code Standards and Libraries used in RL.
3	Implementation of Temporal-Difference Learning Methods.
4	Implementation of Deep Q-networks.
5	Implementation of Policy optimization Methods.

BOOKS RECOMMENDED

1. Richard S. Sutton and Andrew G. Barto, "Reinforcement learning: An introduction", Second Edition, MIT Press, 2019.
2. Li, Yuxi. "Deep reinforcement learning." arXiv preprint arXiv: 1810.06339 (2018).
3. Szepesvári, Csaba. "Algorithms for reinforcement learning." Synthesis lectures on artificial intelligence and machine learning 4, no. 1 (2010): 1-103.
4. Russell, Stuart J., and Peter Norvig. "Artificial intelligence: a modern approach. "Pearson Education Limited, 2016.
5. Wiering, Marco A., and Martijn Van Otterlo. "Reinforcement learning." Adaptation, learning, and optimization 12.3 (2012): 729.

Course Outcomes
At the end of the course, students will

CO1	have a knowledge of the core challenges in designing RL systems and how to approach them.
CO2	be able to define RL tasks and the core principals behind the RL, including policies, value functions, deriving Bellman equations.
CO3	be able to implement in code common algorithms following code standards and libraries used in RL.
CO4	be able to understand and work with tabular methods to solve classical control problems.
CO5	be able to recognize current advanced techniques and applications in RL.

M.Tech. I (CSE) Semester – II	L	T	P	C
CSCS120: DATA MINING AND DATA WAREHOUSING (CORE ELECTIVE 3 OR 4)	**3**	**0**	**2**	**4**

Course Objective	
1	To introduce students to the basic concepts and techniques of Data Mining.
2	To introduce a wide range of association, clustering, estimation, prediction, and classification algorithms.
3	To introduce mathematical statistics foundations of the Data Mining Algorithms.
4	To introduce basic principles, concepts and applications of Data Warehousing.
5	To build a data mining application from a data warehouse to solve real problems.

OVERVIEW	**(05 Hours)**
Introduction, Data Mining Issues, Data Mining Metrics, Data Mining from a Database Perspective, Data Mining Techniques: Classification, Statistical-Based Algorithms, Decision Tree -Based Algorithms, Neural Network-Based Algorithms, Rule-Based Algorithms, Combining Techniques; Similarity and Distance Measures, Hierarchical Algorithms, Partitioned Algorithms, Clustering Large Databases, Clustering with Categorical Attributes; Basic Algorithms, Advanced Association Rule Techniques, Measuring the Quality of Rules	
MINING STREAM, TIME SERIES AND SEQUENCE DATA	**(10 Hours)**
Mining Data Streams, Methodologies for Stream Data Processing and Stream Data Systems, Frequent-Pattern Mining in Data Streams, Classification of Dynamic Data Streams, Clustering Evolving Data Streams; Trend Analysis, Similarity Search in Time Series Analysis, Sequential Pattern Mining in Transactional Databases, Constraint-Based Mining of Sequential Patterns, Periodicity Analysis for Time-Related Sequence Data; Mining Sequence Patterns, Alignment of Sequences, Hidden Markov Model for Sequence Analysis.	
MULTIMEDIA DATA MINING	**(08 Hours)**
Multimedia Data, Similarity Search in Multimedia Data, Multidimensional Analysis of Multimedia Data, Classification and Prediction Analysis of Multimedia Data, Mining Associations in Multimedia Data, Audio and Video Data Mining.	
SPATIAL DATA MINING	**(08 Hours)**
Spatial Data, Mining Spatial Association and Co-location Patterns, Spatial Classification and Spatial Trend Analysis, Spatial Clustering Methods, Mining Raster Databases	
DATA WAREHOUSING	**(08 Hours)**
Review of Data Warehouse, Multidimensional Data Model, Data Cubes, Process Architecture, OLAP Operations, Stream OLAP and Stream Data Cubes, Generalization of Structured Data, Aggregation and Approximation in Spatial and Multimedia Data Generalization, Generalization of Class Composition Hierarchies, Construction and Mining of Object Cubes, Generalization-Based Mining of Plan Databases by Divide-and-Conquer, Spatial Data Cube Construction and Spatial OLAP.	
APPLICATIONS AND OTHER DM TECHNIQUES	**(06 Hours)**
Mining Event Sequences, Visual DM, Data Stream Mining, Multimedia Mining, Spatial Mining.	
Practical assignment will be based on the coverage of the above topics.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

List of Practical (Problem statements will be changed every year and will be notified on the website.)	
1	Implementation of an application of a KDD process.
2	Analysis of Data Mining Techniques with Implementations using Java, Python etc.
3	Implementation of Nearest Neighbor Learning and Decision Trees.
4	Analysis of Splitting and Merging Clusters.
5	Implementation of association rule mining algorithms.
6	Mini Project: Implementation of Selected Journal Papers.

BOOKS RECOMMENDED

1. Jiawei Han, MichelineKamber, "Data Mining: Concepts and Techniques", Morgan Kaufman.
2. Ville, "Decision Trees for Business Intelligence and Data Mining: Using SAS Enterprise Miner", SAS.
3. Pang-Ning Tan, Michael Steinbach, Vipin Kumar, "Introduction to Data Mining", Addison Wesley.
4. Tom Soukup, Ian Davidson, "Visual Data Mining: Techniques and Tools for Data Visualization and Mining", Wiley.
5. Alex Berson, Stephen J. Smith, "Data Warehousing, Data Mining, and OLAP", MGH.

Course Outcomes **At the end of the course, students will**	
CO1	be able to identify the key processes of data mining, data warehousing and knowledge discovery process and understand the basic principles and algorithms used in practical data mining.
CO2	be able to apply data mining techniques to solve problems in other disciplines in a mathematical way.
CO3	be able to analyze the algorithms used in practical data mining and their strengths and weaknesses.
CO4	be able to evaluate different strategies of data warehousing techniques and data mining algorithms.
CO5	be able to design data mining algorithms for real time applications.

M.Tech. I (CSE) Semester – II	L	T	P	C
CSCS122: DATA SCIENCE FOR SOFTWARE ENGINEERING (CORE ELECTIVE 3 OR 4)	3	0	2	4

Course Objective	
1	To understand various tools of Software Engineering.
2	To understand the capability of software engineering principles to analyze data science applications to make appropriate decisions.
3	To learn various methods and principles of software engineering for data science applications.
4	To learn integration of software engineering principles with data science applications.
5	To learn how to use software engineering for data science.

FORMAL SOFTWARE ENGINEERING	(06 Hours)
Formal specifications, Techniques, Verification and Validation, Theorem Provers, Model checking, modeling concurrent systems, Temporal logics, CTL & LTL and model checking, SAT Solvers, Testing Techniques, Test Case Generation	
SOFTWARE REQUIREMENTS AND ESTIMATION	**(04 Hours)**
Software Requirements: What and Why, Software Requirements Engineering, Software Requirements Management, Software Requirements Modeling, Software Estimation, Size Estimation, Effort, Schedule and Cost Estimation, Tools for Requirements Management and Estimation.	
SOFTWARE DEVELOPMENT METHODOLOGIES	**(05 Hours)**
Introduction to Software Engineering, A Generic View of Process, Process Models, Software Requirements, Design Engineering, Creating an Architectural Design, Modeling Component.	
SOFTWARE PROCESS AND PROJECT MANAGEMENT	**(05 Hours)**
Software Process Maturity, Process Reference Models, Software Project Management Renaissance, Life-Cycle Phases and Process artifacts, Workflows and Checkpoints of Process, Process Planning, Project Organizations, Project Control and Process Instrumentation, CCPDS-R Case Study and Future Software Project Management Practices.	
FUNDAMENTALS OF OBJECT ORIENTED DESIGN IN UML	**(05 Hours)**
Static and Dynamic Models, Necessity of Modeling, UML Diagrams, Class Diagrams, Interaction Diagrams, Collaboration Diagram, Sequence Diagram, State Chart Diagram, Activity Diagram, Implementation Diagram.	
USER INTERFACE	**(04 Hours)**
Module Introduction, Objectives of Usability, How to Approach Usability, Designing with Usability in mind, Measuring Usability, Guidelines for User Interface Design, User Interface Elements.	
SOFTWARE QUALITY ASSURANCE AND TESTING	**(04 Hours)**
Software Quality Assurance and Standards, Quality Standards, Software Testing Strategy and Environment, Building Software Testing Process, Software Testing Techniques, Software Testing Tools, Testing Process-Seven Step Testing Process, Specialized Testing Responsibilities.	
DATA SCIENCE PERSPECTIVE FOR SOFTWARE ENGINEERING	**(12 Hours)**
Diverse Sets of Data, Category of Data, Combining Quantitative and Qualitative Methods, Structuring and Summarizing Unstructured Software Data, Validate and Calibrate Data, Generation of Requirement Specifications, Automatic Code Documentation; Software Project Cost Estimation, Software Quality Prediction, Semi-Automatic Refactoring, Prioritization, Automatic Bug Assignment and Test Cases Generation; Case Study-Search Engine: Working of Search Engine, Content Quality Strategy, Control Crawling, Indexing and Ranking, Search Appearance, Optimization.	

Practical Assignments will be based on the coverage of above topics.	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

List of Practical (Problem statements will be changed every year and will be notified on the website.)	
1	Working with software engineering software SPIN.
2	Working with a variety of modules for software engineering.
3	Working with testing of the software project.
4	To develop the software engineering prototype of the application.
5	To analyze the software using a model checker.

BOOKS RECOMMENDED

1. Roger S. Pressman, “Software Engineering: A Practitioner's Approach”, McGraw Hill Higher Education.
2. Ian Sommerville, “Software Engineering”, Pearson Education.
3. Carlo Ghezzi, Mehdi Jazayeri, Dino Mandrioli, “Fundamentals of Software Engineering”, Pearson.
4. Hans van Vliet, “Software Engineering: Principles and Practice”, Wiley.
5. Tim Menzies, Laurie Williams, Thomas Zimmermann, “Perspectives on Data Science for Software Engineering”.

Course Outcomes **At the end of the course, students will**	
CO1	have knowledge about software engineering tools for integrated development environments, syntax checking, testing, debugging, and version control.
CO2	be able to apply software engineering principles to solve Data Science applications.
CO3	be able to critically analyze the Data Science problems to apply software engineering solutions.
CO4	be able to evaluate various Data Science applications using software engineering principles.
CO5	be able to design software engineering principles based applications using Data Science principles.

M.Tech. I (CSE) Semester – II	**L**	**T**	**P**	**C**
CSCS124: SECURITY AND PRIVACY IN SOCIAL NETWORKS (CORE ELECTIVE 3 OR 4)	**3**	**0**	**2**	**4**

Course Objectives	
1	to understand online social media privacy and security issues.
2	to recognize different privacy and security problems on online social media (spam, phishing, fraud nodes, and identity theft).
3	to use online social networks to express a wide range of problems.
4	to use the analysis of security issues and countermeasures to create new knowledge, decisions, and actions.
5	to solve identity problems with understanding of location based privacy.

Introduction To Social Networks Security	**(06 Hours)**
Types and Classification of Social Media, Problems and Opportunities of Social Media- Risks of Social Media, Public Embarrassment, False Information, Information Leakage, Retention and Archiving Content, Backing Up Social Media, Loss of Data/Equipment, Dark Side of Social Media, Cybercrime, Social Engineering, Hacked Accounts; Sharing Information on Social Media.	
Attacks On Social Media and Data Analytics Solutions	**(06 Hours)**
Malware and Attacks, Types of Malware, Threats to Cyber Security, Attacks on Social Media, Data Analytics Solutions, Data Mining for Cyber Security, Malware Detection as a Data Stream Classification Problem, Cloud-Based Malware Detection for Evolving Data Streams, Cloud Computing for Malware Detection, Design and Implementation of the System Ensemble Construction and Updating, Malicious Code Detection.	
Confidentiality, Access Control, Privacy and Trust In Social Media	**(08 Hours)**
CPT Framework and Process, Inference Engines, Confidentiality Management, Privacy for Social Networks, Trust for Social Networks, Security Policies for Social Networks, Access Control System for Social Networks	
Inference Control For Social Media	**(06 Hours)**
Architecture and Design ofan Inference Controller, Inference Control through Query Modification - Query Modification, Query Modification With Relational Data, Sparql Query Modification, Query Modification for Enforcing Constraints, Applications, Use Cases of Inference Controller.	
Secure Query Processing For Social Media	**(06 Hours)**
Secure Cloud Query Processing with Relational Data for Social Media, Secure Cloud Query Processing for Semantic Web-Based Social Media - Access Control and System Architecture.	
Social Network Integration and Analysis With Privacy Preservation	**(09 Hours)**
Social Network Analysis, Limitations of Current Approaches for Privacy-Preserving Social Networks - Privacy Preservation of Relational Data, K-Anonymity and L-Diversity, Privacy Preservation of Social Network Data, Framework of Information Sharing and Privacy Preservation For Integrating Social Networks - Sharing Insensitive Information, Generalization, Probabilistic Model of Generalized Information, Integrating Generalized Social Network For Social Network Analysis Task.	
Advance Topics	**(04 Hours)**
Practical Assignments will be based on the coverage of above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**

(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

Books Recommended

1. Thuraisingham B., Abrol Raymond Heatherly S., Kantarcioglu M., Khadilkar V., Khan L, "Analyzing and Securing Social Networks", Taylor & Francis Group, 2016.
2. Michael Cross, "Social Media Security", Elsevier, 2013
3. Altshuler Y., Elovici Y., Cremers A.B., AharonyN., Pentland, "Security and Privacy in Social Networks", Springer, 2013.
4. Gavin Bell, "Building Social Web Applications",O'Reilly, 2009.
5. Carminati, B., Ferrari, E., Viviani, M, " Security and Trust in Online Social Networks" , Switzerland: Morgan & Claypool Publishers, 2013.

Course Outcomes

At the end of the course, students will

CO1	be able to understand various privacy and security risks (spam, phishing, fraud nodes, identity theft).
CO2	be able to apply the appropriate analytical methodology for fresh research and evaluate the results accurately.
CO3	be able to analyse fraudulent entities in online social networks.
CO4	be able to evaluate algorithm for handling various concerns comprehensively on online social media.
CO5	be able to design the system addressing various privacy issues of frameworks to relate them to techniques and applications.

M.Tech. I (CSE) Semester – II	L	T	P	C
CSCS126: FOUNDATIONS OF PRIVACY ENGINEERING (Core Elective 3 or 4)	3	1	0	4

Course Objectives	
1	to understand the privacy violations and the underlying causes.
2	to learn limitations of statistical disclosure.
3	to integrate privacy into the software engineering lifecycle phases
4	to collect, analyze and reconcile system requirements in a privacy-sensitive ecosystem
5	to evaluate software designs based on privacy principles and privacy requirements.

INTRODUCTION	(09 Hours)
Course Overview and Conceptual Privacy Frameworks. Fair Information Principles. Privacy in Context. Informational Privacy. The Constitutional Right to Privacy. Reductionism vs. Coherentism. Critiques of Privacy. Meaning and Value of Privacy. The Scope of Privacy. Privacy and Technology. Privacy as Contextual Integrity. A Taxonomy of Privacy. Privacy Technologies: Secret sharing and DC nets. The Dining Cryptographers Problem. Mix networks and onion routing. Untraceable Electronic Mail. Tor: The Second-Generation Onion Router. Anonymous communication. Oblivious Transfer and Garbled Circuits. How to Exchange Secrets with Oblivious Transfer. Yao's Garbled Circuits. Evaluating encrypted neural networks	
DATA USE ON THE WEB	**(06 Hours)**
Privacy and Contextual Integrity: Framework and Applications. Summary of the HIPAA Privacy Rule (Permitted Uses and Disclosures, Authorized Uses and Disclosures). A Formalization of HIPAA for a Medical Messaging System. Experiences in the Logical Specification of the HIPAA and GLBA Privacy Laws	
PRIVACY IN REQUIREMENTS	**(10 Hours)**
Requirements: Expressing, Analyze system and privacy requirements using natural language use cases and semi-formal models. Conflicts reconciliation between system requirements and privacy requirements. Sources of requirements, trace matrices to manage compliance. Legal or regulatory requirements, privacy principles, privacy patterns and privacy controls.Goal-based analysis to refine privacy goals into functional, privacy-enhancing system specifications.Privacy threat and risk analysis to apply different risk models to explore privacy threats, vulnerabilities and mitigations, including: a legal compliance model, a FIPs-based model, Calo's subjective/objective harms model, Solove's privacy harms taxonomy, and Nissenbaum's Contextual Integrity.	
PRIVACY IN DESIGN	**(10 Hours)**
Privacy by design. Alternative design strategies to implement requirements.Architecture vs. Policy - Boundary between engineering automation and the human reliance. Translation of policy into system specifications. Data Lifecycle: collection, use, and retention to transfer. Designing for various privacy qualities, including collection and use limitation, data minimization, anonymization or de-identification, destruction, and individual participation, among others.Evolution & Adaptability affecting privacy, including deployment, maintenance and upgrades that risk privacy requirements violation.	
TESTING FOR PRIVACY	**(10 Hours)**
Testing and Validation. TESTING privacy requirements. Accommodating requirements that are not easily tested, privacy-protective activities.Code reviews and code audits, and auditing runtime	

behavior.	
Tutorial Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(15 Hours)**
(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

BOOKS RECOMMENDED

1. Axel van Lamsweerde, "Requirements Engineering: From System Goals to UML Models to Software Specifications" , John Wiley & Sons, Inc. 2009.
2. Vicenç Torra, "Data Privacy: Foundations, New Developments and the Big Data Challenge", Springer, 1st Edition, 2017.
3. The research papers prescribed in the class.
4. Stanford Encyclopedia of Philosophy: Article on Privacy, First Published, 2002. Substantive revision 2018.
5. Stallings, William, " Information Privacy Engineering and Privacy by Design: Understanding Privacy Threats, Technology, and Regulations Based on Standards and Best Practices", United Kingdom, Pearson Education, 2019.

Course Outcomes **At the end of the course, students will be able**	
CO1	To understand the privacy framework and principles
CO2	to integrate privacy into the software engineering lifecycle phases
CO3	to collect, analyze and reconcile system requirements in a privacy-sensitive ecosystem
CO4	to evaluate software designs based on privacy principles and privacy requirements
CO5	to interface with software developers on critical privacy issues

M.Tech. I (CSE) Semester – II	L	T	P	C
CSCS128: MALWARE ANALYSIS AND MITIGATION (CORE ELECTIVE 3 OR 4)	**3**	**0**	**2**	**4**

Course Objective	
1	To identify and describe common traits of malware.
2	To examine and analyse malwares using static and dynamic analysis techniques.
3	To apply different tools for malware detection.
4	To evaluate potential threats due to malware activity on system or network.
5	To create malware analysis report from studied technique and develop mitigation strategies.

INTRODUCTION	**(08 Hours)**
Introduction To Malwares, Different Types of Malwares, Characteristics of Malwares.	
STATIC ANALYSIS	**(12 Hours)**
Identification and Initial Assessment of Malwares, Antivirus Scanning, Hashing, Finding Strings, Packed and Obfuscated Malware, File Formats, Linked Libraries and Functions, X86 Architecture and Disassembly, Recognizing C Code Constructs In Assembly, Analyzing Malicious C Programs, Shellcode Analysis	
DYNAMIC ANALYSIS	**(08 Hours)**
Sandboxes, Process Monitors, Process Explorer, Registry Snapshots, Faking A Network, Packet Sniffing, Source and Assembly Level Debugger, Kernel and User Level Debugging, Exceptions.	
MALWARE FUNCTIONALITY	**(08 Hours)**
Malware Behaviour, Covert Malware Launching, Data Encoding, Malware Focused Network Signatures	
ANTI REVERSE ENGINEERING	**(09 Hours)**
Anti-Disassembly, Anti-Debugging, Anti-Virtual Machine Techniques, Packers and Unpacking	
Practical Assignments will be based on the coverage of above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED

1. Michael Sikorski, andrewHonig, Practical Malware Analysis: The Hands-On Guide to Dissecting Malicious Software publisher William Pollock, 2012.
2. Michael Hale Ligh, andrew Case, Jamie Levy, AAron Walters, The Art of Memory Forensics: Detecting Malware and Threats in Windows, Linux, and Mac Memory, 2014.
3. Ligh, M., Adair, S., Hartstein, B., Richard, M., “Malware analyst's cookbook and DVD: tools and techniques for fighting malicious code”, Wiley Publishing, 2010.
4. Marak V., “Windows malware analysis essentials”, Packt Publishing Ltd, 2015.
5. Dang, B., Gazet, A., Bachaalany, E., “Practical reverse engineering: x86, x64, ARM, Windows kernel, reversing tools, and obfuscation”, John Wiley & Sons, 2014.

Course Outcomes At the end of the course, students will	
CO1	have the knowledge of different types of malware, its behavior and analysis techniques.
CO2	be able to apply different tools and techniques for malware data acquisition and analysis.
CO3	be able to analyse the effect of malware on system and network.
CO4	Be able to evaluate potential threats due to malware activity on system or network.
CO5	be able to create malware analysis report and suggest suitable preventive measures.

M.Tech. I (CSE) Semester – II	**L**	**T**	**P**	**C**
CSCS130: SECURE SOFTWARE ENGINEERING (CORE ELECTIVE-3 OR 4)	**3**	**0**	**2**	**4**

Course Objective	
1	to understand the limitations of the security software and the motivation of designing secure software based on engineering principles.
2	to enumerate the security attacks at the various layers of the tcp/ip protocol suite as well as in the different phases of the sdlc.
3	to learn the common weaknesses in the memory unsafe and memory safe languages.
4	to analysethe code using static and dynamic analysis tools for security testing.
5	to design a secure model of the software using the attack trees, attack patterns and extensions to the uml for security.
6	to apply the principles learnt throughout the requirements analysis, specifications, design and implementation of the software.

INTRODUCTION	**(02 Hours)**
Introduction to the course. Review of Information Security concepts. The CIA Triad. Systems Security, Information Security, Application Security, Network Security – commonalities and differences. Essential Terminologies.Secure Software & its properties. Security Software: Critical shortcomings. Studies of various catastrophes due to Insecure software. What is Software Security? Software Assurance? Motivation for the Software Security. Software Security vs Security Software. The trinity of troubles viz. Connectivity, Extensibility and Complexity. Model Based Security Engineering. Security in Software Development Lifecycle (SDLC). Software Security Best Practices applied to various software artifacts in the SDLC. Addressing security throughout the SDLC. Three Pillars of Software Security. Software Security Touchpoints.	
SECURITY ATTACKS AND TAXONOMY OF SECURITY ATTACKS	**(02 Hours)**
Review of security attacks – Taxonomy of Security Attacks, Methods. Attacks in each phase of software life cycle. Attacks on the TCP/IP protocol suite layers. Motivation for attackers, Methods for attacks: Malicious code, Hidden software mechanisms, Social Engineering attacks, Physical attacks. Non-malicious dangers to software. The Denial of Service Attacks in each phase of software life cycle. Security Vulnerabilities and Attack Taxonomy in Internet of Things and Cyber Physical Systems. Review of Malwares: Viruses, Trojans, and Worms. Malware Terminology: Rootkits, Trapdoors, Botnets, Key loggers, Honeypots. IP Spoofing, Tear drop,DoS, DDoS attacks.	
THE SOFTWARE VULNERABILITIES	**(09 Hours)**
The Software Vulnerabilities: Vulnerabilities in the Memory-safe and memory-unsafe languages. Introduction to the Program Stack Analysis. Hands-on on Stack Analysis using gcc compiler and gdb debugger tool. Methods of security attack exploiting the vulnerabilities in the code. Taxonomy of security vulnerabilities. Remote Code Execution. State-of-the-art in research in Security Vulnerabilities. Overview of C, C++, Java Security Vulnerabilities.	
THE WEB VULNERABILITIES & COUNTERMEASURES	**(09 Hours)**
The common Web vulnerabilities: the Buffer Overflow - Stack overflows, Heap Overflows, the Code and Command Injections and the types: SQL injection, Cross-site scripting, Interpreter injection; the Format String vulnerabilities, writing shellcode. The Seven Pernicious Kingdoms. The Hidden form fields, Weak session cookies. Fault injection & Fault monitoring, Fail open authentication The OWASP Top 25 vulnerabilities in the current year.	

THE WEB VULNERABILITIES IN MEMORY SAFE LANGAUGES & COUNTERMEASURES	**(09 Hours)**
Introduction to Session Management in Web Applications. Session Management best practices. The XSRF (Cross-site Request Forgery) Attack. Security vulnerabilities in Java: Connection String Injection, LDAP Injection, Reflected XSS, Resource Injection, Persistent XSS attacks in Java, The XPath Injection. Insecure deserialization, Remote code execution (RCE).Log injection. Mail injection. Vulnerabilities in Java libraries. Vulnerabilities in the Java sandboxing mechanism. Insufficient Transport Layer Protection (ITLP). Application misconfiguration and Software Composition Analysis (SCA).	
CODE REVIEWS AND STATIC ANALYSIS OF THE SOURCE CODE	**(04 Hours)**
Introduction to Code reviews and Static Informal reviews, Formal inspections. Illustrations. Introduction to Code reviews and Static Analysis. Code Reviews. Static Code Analysis. Static and Dynamic Application Security Testing (SAST and DAST)tools. Using basic linting to detect security vulnerabilities in the code with the linuxfind(), grep(), awk(), splint() and the FlawFinder. A glance at Code Analyzer Tools :Top-10: Raxis, SonarQube for Code Quality and Code Security, PVS-Studio, reshift, Embold, SmartBear Collaborator, CodeScene Behavioral Code Analysis, RIPS Technologies.Others: Cscope, Ctags, Editors, Cbrowser. Comparison with the Dynamic Application Security Testing.	
THREAT MODELLING	**(06 Hours)**
Finding Threats: Using STRIDE, Attack Patterns, Attack Trees, Misuse Patterns. Threat modelling with Attack Trees and Graphs. Anti-models. State transition diagrams. Access control models. Specifying Secrecy, Authentication and Assertions. Graph based specifications, UML-based specifications. Formal Security specifications. Web Threats, Cloud Threats, Mobile Threats, Threats to Cyrptosystems. Attack Libraries: Properties, OWASP Top Ten, CAPEC. Threat Modelng tools: Secure Design – Principles: Secure Software Design Principles and Practices. Security Architectures. Design oriented, Goal oriented and Problem oriented approaches. Security Patterns: Modelling and Classification of Security Patterns. Patterns characterization. Security Design Approaches viz. UML, Secure UML, UMLSec and Misuse cases. Illustrating the design of a security protocol.	
SECURITY IN DESIGN	**(04 Hours)**
Secure Design – Principles: Secure Software Design Principles and Practices. Security Architectures. Design oriented, Goal oriented and Problem oriented approaches. Security Patterns: Modelling and Classification of Security Patterns. Patterns characterization. Security Design Approaches viz. UML, Secure UML, UMLSec and Misuse cases. Illustrating the design of a security protocol.	
Practical Assignments Will Be Based onthe Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED

1. Andrew Magnusson, "Practical Vulnerability Management: A Strategic Approach to Managing Cyber Risks".
2. H Mouratidis, "Software Engineering for Secure Systems – Industrial and Research Perspectives", Information Science Reference, IGI global, 2011.
3. Gary McGraw, "Software Security : Building Security In", Addison Wesley Software Security Series, 2006 edition.
4. Theodor Richardson, Charles Thies, "Secure Software Design. Jones and Bartlet Learning", 2013
5. Malcolm McDonald, "Web Security for Developers: Real Threats", Practical Defense by

ADDITIONAL BOOKS RECOMMENDED
1. Steven Palmer, "Web Application Vulnerabilities: Detect, Exploit, Prevent by". 2. IzarTarandach, "Threat Modeling: A Practical Guide for Development Teams". 3. Tanya Janca, "Alice and Bob Learn Application Security".

Course Outcomes **At the end of the course, students will**	
CO1	have a knowledge of the limitations of the security software and the need for the software security
CO2	be able to apply the concepts of software security learnt, to detect security vulnerabilities and prevent them.
CO3	be able to analyze the security issues in the Requirements, in the Specifications, in the Design and that in the software code.
CO4	be able to design the threat models and security mis-use case diagrams to model the security threats the software being developed.
CO5	be able to use the concepts of information security to prevent security design faults.

M.Tech. I (CSE) Semester – II	L	T	P	C
CSCS132: MOBILE SECURITY AND PENETRATION TESTING (CORE ELECTIVE 3 OR 4)	3	0	2	4

Course Objectives	
1	to understand the importance of security issues in the mobile applications.
2	to enumerate the security vulnerabilities and exploits in the given applications on the android and the ios platforms.
3	to learn how the vulnerabilities are used to create an exploit for the applications on the android and the ios platforms.
4	to analyse software applications on the android and the ios platforms for the security issues therein.
5	to design the secure code and applications for the android and the ios platforms.
6	to apply the knowledge acquired to implement secure software for the android and the ios platforms.

BACKGROUND & INTRODUCTION	(03 Hours)
Introduction to the course. Review of the Mobile Application Security Landscape. The SmartPhone Market. The Android and iOS Operating Systems. Public Android and iOS Operating Systems Vulnerabilities. Key Challenges. Mobile Application Penetration Testing Methodology. The OWASP Mobile Security Project.	
THE ANDROID AND THE IOS ARCHITECTURES & TEST ENVIRONMENTS.	**(07 Hours)**
The Linux Kernel, the Android and the IOS architectures, the Java Virtual Machine, Core Java Libraries, The Application Layer and the the application framework. The Android Application Components. The IOS Application Programming Languages, IOS Security Model. Hardware Level Security and Jailbreaking. The Mach-O binary file format. Mobile app penetration testing environment setup. The Android Studio and SDK. Genymotion. Configuring the emulator for http proxy. Google Nexus-5 physical device. SSH clients. Various tools in the IoS: Cydia, BigBoss, Darwins, iPA Installer, tcpdump, ios SSL Kill-switch. Emulators and simulators.	
MOBILE PENETRATION TOOLS	**(08 Hours)**
Android Security Tools: APKAnalyzer, Thedrozer tool, APKTool, the dex2jar API, JD-GUI, Androguard, Working with the Java debugger. iOS Security Tools: oTool, SSL Kill-switch, The Keychain dumper, LLDB, Clutch, Class-dump-z, Cycript, Frida, Hopper, Snoop-it.	
THREAT MODELLING A MOBILE APPLICATION	**(10 Hours)**
Basic concepts of threat modelling, Threats, Vulnerabilities, Risks. Approaches to Threat Model. Threat Agents in the mobile applications. How to create a threat model? Using STRIDE, PASTA, Trike in Mobile Applications. Building Attack Plans, Threat Trees, Using Attack Patterns for Mobile Applications. Risk Assessment Models.	
ATTACKING ANDROID AND IOS APPLICATIONS	**(09 Hours)**
Attacking Andriod Applications: Setting up the target app. Analzing apps using tools. Attacking activities, services, broadcast receivers, content providers, WebViews, SQL Injection, Man-in-the-middle attacks, SSL Spinning, Hardcoded credentials. Storage/archive analysis. Log analysis. Binary Patching. Attacking iOS applications: Setting up the target app. Storage/archive analysis. Reverse Engineering. Static code analysis. App patching, Runtime manipulation using. Cycript. Dumpdecrypted. Client-side injections. Man-in-the-middle attacks, SSL cert pinning. Building a remote tracer using LLDB	
SECURING ANDROID AND IOS APPLICATIONS.	**(08 Hours)**
Secure by design. Secure mind map for developers. Device level, platform level, application-level protection. iOS cookie and keychains, App Storage protection. Application permissions. Securing	

Webview. Binary protection. Network level protection. OWASP mobile app security checklist. Secure coding Best practices for Android, iOS.	
Practical Assignments will be based on the coverage of above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED

1. Vijay Kumar Velu, “Mobile Application Penetration Testing” , Packt Publishing Limited, 2016.
2. Jeff McWherter, Scott Gowell, “Professional Mobile Application Development”, Wrox Publications, 2012.
3. David Thiel ,“iOS Application Security: The Definitive Guide for Hackers and Developers”, No Starch Press, 2016.
4. David Rogers , “Mobile Security: A Guide for Users”, Lulu.com publishers 2013.
5. Kunal Relan , “ iOS Penetration Testing: A Definitive Guide to iOS Security”, Apres Publications, 2017.

Course Outcomes At the end of the course, students will	
CO1	have a knowledge of the limitations of the security software and the need for the software security
CO2	be able to apply the concepts of software security learnt, to detect security vulnerabilities and prevent them.
CO3	be able to analyze the security issues in the Requirements, in the Specifications, in the Design and that in the software code.
CO4	be able to use the concepts of information security to prevent security design faults.
CO5	be able to design the threat models and security mis-use case diagrams to model the security threats the software being developed.

M.Tech. I (CSE) Semester – II	L	T	P	C
CSCS134: BITCOIN AND CRYPTOCURRENCY TECHNOLOGIES (CORE ELECTIVE 3 OR 4)	3	0	2	4

Course Objectives	
1	to demonstrate a familiarity with the fundamentals of cryptocurrencies.
2	to understand different cryptographic primitives and their use in the design of cryptocurrencies.
3	to analyze different cryptocurrencies and to assess the pros and cons of different cryptocurrencies.
4	to design decentralized applications that operates using cryptocurrencies.
5	to propose and evaluate different use cases of cryptocurrencies.

FUNDAMENTALS OF BLOCKCHAIN TECHNOLOGY AND CRYPTOGRAPHY	(09 Hours)
Centralization vs. Decentralization, Distributed Consensus, Consensus Without Identity, Blockchain, Incentives and Proof of Work, Digital Signature, Tamper Proof Ledger, Distributed Consensus, Proof of Work, Mining and Currency Supply, Cryptographic Hash Functions, Hash Pointers and Data Structures, Digital Signatures, Public Keys as Identities	
BITCOIN - A CRYPTOCURRENCY	**(10 Hours)**
Bitcoin Transactions, Bitcoin Scripts, Applications of Bitcoin Scripts, Bitcoin Blocks, Bitcoin Network, Peer-to-Peer Network Architecture, Limitations & Improvements, Bitcoin Mining, Consensus, Decentralized Consensus, Mining Nodes, Bitcoin Addresses, Wallets, Alternative Chains, Bitcoin Security, Ways to Store and Use Bitcoins	
ETHEREUM	**(10 Hours)**
Ethereum and Turing Completeness, Wallet, Transactions, Metamask, Ether, Externally Owned Accounts (EOAs) and Contracts, Block Explorer, Ethereum Clients, Ethereum Networks, Smart Contracts and Solidity, Smart Contract Security, Ethereum Virtual Machine, Comparison of Bitcoin and Ethereum.	
OTHER CRYPTOCURRENCIES	**(09 Hours)**
Stellar: Stellar Network, Consensus Protocol, Ledger Format, Transactions, Smart Contracts, Monero: Cryptonote protocol, Transactions, Mining, Ring Signatures, Zcash: Zero Knowledge Proofs, Mining, Comparison between Bitcoin, Ethereum, Monero, Zcash, and Other Cryptocurrencies.	
FINTECH AND APPLICATIONS	**(07 Hours)**
Hot and Cold Storage, Splitting and Sharing Keys, Online Wallets and Exchanges, Payment Services, Transaction Fees, Currency Exchange Markets, Building the Blockchain, Crypto Finance, Business Use Cases, Blockchain in Gaming, Investing in Blockchain, Government and Regulation, FinTech.	
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED
1. Andreas M. Antonopoulos, “Mastering Bitcoin: Programming the Open Blockchain”, Shroff/O'Reilly, 2017.

2. Antonopoulos, Andreas M. and Wood, Gavin, "Mastering Ethereum", O'Reilly Media, Inc., 2018.
3. Arvind Narayanan, Joseph Bonneau, Edward Felten, andrew Miller, Steven Goldfeder, "Bitcoin and Cryptocurrency Technologies: A Comprehensive introduction", Princeton University Press, 2016.
4. Franco, Pedro, " Understanding Bitcoin: Cryptography, engineering and economics", John Wiley & Sons, 2014.
5. Elrom, Elad, "The blockchain developer: A Practical Guide for Designing, Implementing, Publishing, Testing, and Securing Distributed Blockchain-based Projects" , Apress, 2019.

Course Outcomes At the end of the course, students will	
CO1	have knowledge about the design principles of blockchain and cryptocurrencies.
CO2	be able to program and demonstrate the working of different consensus mechanisms.
CO3	be able to analyse Cryptocurrency transactions, scripts, and network.
CO4	be able to design decentralized applications that relies on cryptocurrencies.
CO5	be able to analyse the strengths and weaknesses of various cryptocurrencies.

M.Tech. I (CSE) Semester – II	**L**	**T**	**P**	**C**
CSCS136: SECURITY PROTOCOLS (CORE ELECTIVE 3 OR 4)	**3**	**0**	**2**	**4**

Course Objectives	
1	to understand concepts of security protocols and its analysis.
2	to understand how applications can communicate securely and what tools and protocols exist in order to offer different levels of security.
3	to get knowledge and the ability to critically analyze and design secure networks, applications and systems.
4	to give hands-on experience in using automated tools and formal techniques to analyze and evaluate cryptographic protocols and other security mechanisms.
5	to analyze various existing protocols in terms of the goals.

INTRODUCTION TO SECURITY PROTOCOLS	**(04 Hours)**
Introduction to Computer Security, Security Protocols, Security Analysis	
TRANSPORT LAYER SECURITY	**(05 Hours)**
Overview of SSL/TLS, Creating An Abstract Model, Coding Up inMurphi, Specification and Verification of Security Properties.	
KEY EXCHANGE PROTOCOLS	**(04 Hours)**
Key Management, Kerberos, Public-Key infrastructure, Security Properties and Attacks on Them, Needham-Schroeder Lowe Protocol, Diffie-Hellman Key Exchange, IPSec, Ike.	
CONTRACT-SIGNING PROTOCOLS	**(05 Hours)**
Fundamental Limitation of Contract-Signing and Fair-Exchange, Trusted Third Party, Optimistic Contract-Signing, Asokan-Shoup-Waidner Protocol, Desirable Properties (Fairness, Timeliness, Accountability, Balance), Abuse-Free Contract-Signing.	
PASSWORD AUTHENTICATION	**(04 Hours)**
Hashed Password Files and Salt, Web Authentication Issues: Sniffing, Phishing, Spyware, Password-Authenticated Key Exchange Protocols.	
PROBABILISTIC MODEL CHECKING	**(05 Hours)**
Crowds System, Probabilistic Notions of Anonymity, Markov Chains, Prism, PCTL Logic, Probabilistic Fair Exchange.	
PROTOCOL VERIFICATION BY THE INDUCTIVE METHOD	**(04 Hours)**
Protocol Analysis Using Theorem Proving, inductive Proofs, Isabelle Theorem Prover, Verifying the Secure Electronic Transactions (Set) Protocols Using Isabelle.	
PROBABILISTIC CONTRACT SIGNING	**(04 Hours)**
Rabin's Beacon, Rabin's Contract Signing Protocol, BGMR Probabilistic Contract Signing, formal Model forthe BGMR Protocol.	
GAME-BASED VERIFICATION OF FAIR EXCHANGE PROTOCOLS	**(04 Hours)**
The Problem of Fair Exchange, Protocol As A Game Tree, Alternating Transition Systems, Alternating-Time Temporal Logic, Mocha Model Checker.	
OTHER SECURITY PROTOCOLS	**(06 Hours)**
Yahalom Protocol: Secrecy, Authentication, Non-Repudiation, Anonymity; Dolev-Yao Threat Model, Needham- Schroeder Public-Key Protocol and Its Security Analysis. Wireless Networking Protocol, Logic for Computer Security Protocols: Floyd-Hoare Logic of Programs, Ban Logic, Compositional Logic for Proving Security Properties of Protocols, Probabilistic Polynomial-Time Process Calculus for	

Security Protocol Analysis.	
Practical Assignments will be based on the coverage of above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED	
1	Peter Ryan, Steve Schneider, Michael Goldsmith, Gavin Lowe, Bill Roscoe: Modelling & Analysis of Security Protocols, Addison Wesley, 2000.
2	Stephen W. Mancini, "Automating Security Protocol Analysis", Biblioscholar, 2012.
3	Ulysess Black, "internet Security Protocols**:** Protecting IP Traffic**",** Prentice Hall PTR; 1st edition, ISBN-10: 0130142492, ISBN-13: 978-0130142498, 2000.
4	Giampaolo Bella, "formal Correctness of Security Protocols", Springer, 2007.
5	Dinesh Goyal, S. Balamurugan, Sheng-Lung Peng, O.P. Verma, "Design and Analysis of Security Protocol for Communication, Scrivener Publishing, 2020.

Course Outcomes **At the end of the course, students will**	
CO1	be able to understand different authentication techniques, key exchange protocols and security issues while designing the protocols.
CO2	be able to get a hands-on exposure to the principles and techniques used in security systems, as well as designing security protocols.
CO3	be able to analyse the security protocols against different attacks.
CO4	be able to evaluate vulnerabilities in the security systems
CO5	be able to design a key agreement or key transport or key establishment protocol satisfying various security goals.

M.Tech. I (CSE) Semester – II	L	T	P	C
CSCS138: HARDWARE SECURITY (CORE ELECTIVE 3 OR 4)	**3**	**0**	**2**	**4**

Course Objectives	
1	to understand hardware based security primitives and protocols
2	to identify security threats for modern hardware design and practices
3	to understand different defense techniques to secure hardware
4	to explore practical real world case studies to design secure hardware

INTRODUCTION TO HARDWARE SECURITY	**(04 Hours)**
Overview and Layers of Computing System, Hardware Trust and Security, Attacks, Vulnerabilities, and Countermeasures, Conflict Between Security and Test/Debug	
HARDWARE TROJANS	**(07 Hours)**
Introduction, SoC Design Flow, Hardware Trojans, Hardware Trojans in FPGA Designs, Hardware Trojans Taxonomy, Trust Benchmarks, Countermeasures Against Hardware Trojans, Hands-on Experiment: Hardware Trojan Attacks	
HARDWARE IP PIRACY AND REVERSE ENGINEERING	**(07 Hours)**
Introduction, Hardware intellectual Property (IP), Security Issues in IP-Based SoC Design- Hardware Trojan Attacks, IP Piracy and Overproduction, Reverse Engineering, Security Issues in FPGA- FPGA Preliminaries, Lifecycle of FPGA-Based System, Hands-on Experiment: Reverse Engineering and Tampering	
SIDE-CHANNEL ATTACKS	**(08 Hours)**
Taxonomy of Side-Channel Attacks, Power Analysis Attacks-, Higher-order Side-Channel Attacks, Electromagnetic (EM) Side-Channel Attacks, Fault injection Attacks, Timing Attacks, Covert Channels.	
PCB SECURITY	**(08 Hours)**
PCB Security Challenges, Attacks on PCB, PCB Authentication, Sources of PCB Signature, Signature Assessment Metric, PCBintegrity Validation.	
HARDWARE SECURITY PRIMITIVES	**(07 Hours)**
Physically Unclonable Function, True Random Number Generator, Design for Anti-Counterfeit, Hardware Obfuscation, Use of Obfuscation Against Trojan Attacks	
ADVANCED TOPICS	**(04 Hours)**
Practical Assignments will be based on the coverage of above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED

1. Ahmad-Reza Sadeghi, David Naccache. towards Hardware-intrinsic Security, Springer, 2010.
2. Debdeep Mukhopadhyay and RajatSubhra Chakraborty, Hardware Security: Design, Threats, and Safeguards, CRC Press.
3. Stefan Mangard, Elisabeth Oswald, Thomas Popp. Power analysis attacks - revealing the secrets of smart cards. Springer 2007.
4. Rebeiro Chester, Mukhopadhyay Debdeep, Bhattacharya Sarani. Timing Channels in Cryptography A Micro-Architectural Perspective. Springer. 2015.
5. Ted Huffmire et al. Handbook of FPGA Design Security, Springer. 2014.

Course Outcomes At the end of the course, students will	
CO1	be able to understand hardware security concepts
CO2	be able to assess the security of different hardware designs
CO3	be able to apply different hardware security techniques for modern hardware designs
CO4	be able to implement and evaluate different hardware security techniques.
CO5	be able to design secure hardware systems

M.Tech. I (CSE) Semester – II	L	T	P	C
CSCS172: SOCIAL NETWORKS (INSTITUTE ELECTIVE)	**3**	**0**	**0**	**3**

Course Objectives	
1	To understand the social network models, representation and analytics.
2	To identify the unique challenges involved in social network research.
3	To apply techniques for social network representation and analytics for real-word scenarios.
4	To analyse and evaluate the social network research solutions for real-world scenarios.

INTRODUCTION	**(09 Hours)**
Introduction To Social Networks: Networks as Information Maps, Networks as Conduits, Connections, Propinquity, Homophily	
SOCIAL NETWORK REPRESENTATION	**(18 Hours)**
Social Network Analysis: Mathematical Foundations, Data Collection, Data Management, Visualization, Centrality, Subgroups, Cliques, Clusters, Dyads and Triads, Density, Structural Holes, Weak Ties, Centrality, The Small World, Circles, and Communities, Multiplicity, Structural Similarity and Structural Equivalence	
SOCIAL NETWORK ANALYSIS	**(09 Hours)**
Social Networks and Diffusion: Influence and Decision-Making, Epidemiology and Network Diffusion, Tipping Points and Thresholds	
TOOLS AND CASE STUDIES	**(09 Hours)**
Social Network Tools and Case Studies	
	(Total Contact Time: 45 Hours)

BOOKS RECOMMENDED

1. Borgatti SP, Everett MG, Johnson JC, “Analyzing Social Networks”, London, Sage Publication, 2013.
2. Kadushin C., “Understanding Social Networks: Theories, Concepts and Findings”, Oxford University Press, 2012.
3. Piet A.M. Kommers, Pedro Isaias, Tomayess Issa, “Perspectives on Social Media: A Yearbook”, Taylor and Francis, 2014.
4. Newman Mark, “Networks: An Introduction”, Oxford university press, 2018.
5. Brath Richard, David Jonker, "Graph analysis and visualization: Discovering Business Opportunity in Linked Data", John Wiley & Sons, 2015.

Course Outcomes At the end of the course, students will	
CO1	have the knowledge of various social network representation, visualization and analytics tools and techniques.
CO2	be able to apply tools for social network data acquisition, management and analytics.
CO3	be able to analyse the social network research solutions for real-world scenarios
CO4	be able to evaluate different methods for social network representation and analytics.
CO5	be able to design the social network analytics solution for the complex real-world problem.

M.Tech. I (CSE) Semester – II	**L**	**T**	**P**	**C**
CSCS174: CYBER LAWS (INSTITUTE ELECTIVE)	**3**	**0**	**0**	**3**

Course Objective	
1	The course aims at acquainting the students with the basic concepts of Cyber Law and also puts those concepts in their practical perspective.
2	It also provides an elementary understanding of the authorities under IT Act as well as penalties and offences under IT Act.
3	It also covers overview of Intellectual Property Right and Trademark Related laws with respect to Cyber Space.
4	Student will get the knowledge about the E- Governance policies of India.

INTRODUCTION OF CYBER CRIMES & CYBER LAW	**(07 Hours)**
Understanding Cyber Crimes and Cyber Offences, Crime in context of Internet, Types of Crime in Internet, Crimes targeting Computers: Definition of Cyber Crime & Computer related Crimes, Constraint and Scope of Cyber Laws, social media and its Role in Cyber World, Fake News, Defamation, Online Advertising.	
PREVENTION OF CYBER CRIMES & IT ACT 2000	**(07 Hours)**
Prevention of Cyber Crimes & Frauds, Evolution of the IT Act 2000, Genesis and Necessity. Critical analysis & loop holes of The IT Act, 2000 in terms of cyber-crimes, Cyber Crimes: Freedom of speech in cyber space & human right issues.	
FEATURES OF IT ACT 2000 & AMENDMENTS	**(07 Hours)**
Salient features of the IT Act, 2000, Cyber Tribunal & Appellate Tribunal and other authorities under IT Act and their powers, Penalties & Offences under IT Act, Amendments under IT Act and Impact on other related Acts (Amendments): (a) Amendments to Indian Penal Code. (b) Amendments to Indian Evidence Act. (c) Amendments to Bankers Book Evidence Act. (d) Amendments to Reserve Bank of India Act.	
INDIAN PENAL LAW	**(06 Hours)**
Indian Penal Law and Cyber Crimes: (i) Fraud, (ii) Hacking, (iii) Mischief, Trespass (iv) Defamation (v) Stalking (vi) Spam, Issues of Internet Governance: (i) Freedom of Expression in Internet (ii) Issues of Censorship (iii) Hate Speech (iv) Sedition (v) Libel (vi) Subversion (vii) Privacy, Cyber Appellate Tribunal with Special Reference to the Cyber Regulation Appellate Tribunal (Procedures) Rules 2000.	
GLOBAL IT RULES & IPR	**(06 Hours)**
The Information Technology (Procedures and Safeguards for Interception, Monitoring and Decryption of Information) Rules, 2009 and Corresponding International Legislation in US, UK and Europe, The Information Technology (Procedures and Safeguards for Blocking the access of Information by Public) Rules, 2009 and Corresponding International Legislation in US, UK and Europe, The Information Technology (Reasonable Security Practices and Procedures and Sensitive Personal Data or Information) Rules, 2009 and Corresponding International Legislation in US, UK and Europe, Intellectual Property Right (IPR).	
CYBER SPACE & E-GOVERNANCE IN INDIA	**(06 Hours)**
Cyber and Cyber Space with reference to Democracy and Sovereignty, Developments in Cyber law Jurisprudence, Role of law in Cyber World: Regulation of Cyber Space in India, Role of RBI and Legal Issues in case of e-commerce, E-Governance in India: Law, Policy, Practice.	

CYBER SPACE JURISDICTION	**(06 Hours)**
Cyber Space Jurisdiction (a) Jurisdiction issues under IT Act, 2000. (b) Traditional principals of Jurisdiction (c) Extra-terrestrial Jurisdiction (d) Case Laws on Cyber Space Jurisdiction (e) Taxation issues in Cyberspace.	
	(Total Contact Time: 45 Hours)

BOOKS RECOMMENDED

1. Vakul Sharma , "Information Technology Law and Practice- Cyber Laws and Laws Relating to E-Commerce", Universal Law Publishing - An imprint of LexisNexis.
2. Duggal Pavan , "Legal Framework on Electronic Commerce and Intellectual Property Rights in Cyberspace", Universal Law Publishing - An imprint of LexisNexis.
3. Yatindra Singh , "Cyber Laws: A Guide to Cyber Laws, Information Technology, Computer Software, Intellectual Property Rights, E-commerce, Taxation, Privacy, Etc. Along with Policies, Guidelines and Agreements", Universal Law Publishing
4. Santosh Kumar, "Cyber Laws & Cyber Crimes", WHITESMANN.
5. Akash Kamal Mishra , "Cyber Laws in India - Fathoming Your Lawful Perplex " , Notion Press, 2020.

Course Outcomes At the end of the course, students will	
CO1	be able to understand the types of Crime in Internet, Crimes targeting Computers and Scope of Cyber Laws.
CO2	be able to apply the cyber laws to related the various evidences of cybercrimes.
CO3	be able to analyze the various evidences of cybercrimes to allied with the particular cyber law.
CO4	be able to evaluate the particular intellectual property rights according to the cyber law.
CO5	be able to design an application to counter the cybercrimes.

M.Tech. I (CSE) Semester – II	L	T	P	C
CSCS176: ETHICAL HACKING AND PENETRATION TESTING (INSTITUTE ELECTIVE)	**3**	**0**	**2**	**4**

Course Objectives	
1	To DESCRIBE the fundamental concepts of protecting a network from attacks.
2	To ENUMERATE the techniques for collecting the network and the host information by a remote user.
3	To LEARN the techniques by which the adversary can discover and do mapping of systems, can orchestrate unauthorized manipulation of data, disable network systems or services and deny access to resources by legitimate users.
4	To ANALYSE the techniques used by the adversary to detect the common vulnerabilities.
5	To APPLY the knowledge gained to protect the network as well as the host systems from the adversary attacks.

INTRODUCTION	**(04 Hours)**
Review of the Network Fundamentals, Network Topologies, Network Components, TCP/IP Networking Basics, TCP/IP Protocol Stack: DNS, SNMP, TCP, UDP, IP, ARP, RARP, ICMP protocols. Ethernet, Subnet Masking, Subnetting, Supernetting. Review of the Security Basics: Attributes, Mechanisms and Attacks Taxonomy. The CIA Traid. Threats, Vulnerabilities, Attacks	
NETWORK SECURITY CONCERNS	**(04 Hours)**
Network Security Concerns. Fundamental Network Security Threats. Types of Network Security Threats. Network Security Vulnerabilities, their types: Technological Vulnerabilities, Configuration Vulnerabilities, Security policy Vulnerabilities. Types of Network Security Attacks	
INTELLIGENCE (INT) GATHERING	**(09 Hours)**
Learning about the target, its business, its organizational structure, and its business partners. To output the list of company names, partner organization names, and DNS names, and the servers. The concepts of Search engines, Financial databases, Business reports. The use of WHOIS, RWHOIS, Domain name registries and registrars, Web archives and the corresponding open source tools for mining these data. Cloud reconnaissance.	
NETWORK FOOTPRINTING	**(09 Hours)**
Active & Passive Footprinting. Network and system footprinting. Tools for network footprinting. Using Search engines to find the tools. Mining the DNS host names, corresponding IP addresses, IP address ranges, Firewalls, Network maps. Use of search engines, social media, social engineering, the websites of the target organization. Using archive.org. Using Neo trace, *DNS Footprinting* and whois databases. Use of the contemporary tools (e.g. png, port scanners) for finding these information. Email footprinting. Email Tracking. Footprinting through Google tools. Using traceroute. Verification to confirm the validity of information collected in the prior phases. The countermeasures to prevent successful network footprinting.	
SCANNING & ENUMERATION	**(09 Hours)**
Scanning: goals and type, overall scanning tips, sniffing with tcpdump, network tracing, port scanning. OS fingerprinting, version scanning. Identify open ports. Web Service Review Tools: Identify web-based vulnerabilities. Network Vulnerability Scanning Tools: Identify infrastructure-related security issues. The illustrative tools are Nmap, ping, AngryIP, Nikto, OpenVAS, udp-proto-scanner, Netsparker, Nessus, Masscan, SQLMap, Nexpose, Burpsuite, Qualys, HCL AppScan, Amass, wpscan, Eyewitness, WebInspect, ZAP. Stealth Scannning: Scanning Beyond an IDS. Network diagram generation using typical tools viz. Network Topology Mapper, OpManager, LANState, Friendly Pinger. Proxy Servers, The Onion Routing.	

http tunneling. ssh tunneling. Anonymizers.	
EXPLOITATION	**(10 Hours)**
Network based exploitation: using tools a such as Metasploit to compromise vulnerable systems, basics of pivoting, and pilfering. Detection of IP Spoofing. Common web vulnerabilities: Cross-site scripting, OS and Command injections, Buffer overflows, SQL injection, race conditions, and such other vulnerabilities scanning and exploitation techniques, including those in OWASP Top 25. Extracting information about the user names using email IDs, the list of default passwords used by the products used at the target, user names using the SNMP protocol, user groups from Windows and the DNS zone transfer information. SuperScan. Route Analysis Tools. SNMP Enumeration. Reconnaissance Attacks and how to mitigate reconnaissance attacks.	
Practical Assignments will be based on the coverage of above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED

1. John Slavio, “Hacking: A Beginners’ Guide to Computer Hacking, Basic Security, And Penetration Testing”.
2. Yuri Diogenes, Dr. ErdalOzkaya, “Cybersecurity – Attack and Defense Strategies: Counter modern threats and employ state-of-the-art tools and techniques to protect your organization against cybercriminals”, 2nd Edition Kindle Edition, Packt Publishing; 2019.
3. Hidaia Mahmood Alassouli, “Footprinting, Reconnaissance, Scanning and Enumeration Techniques of Computer Networks”, Blurb Publishers.
4. Robert Shimonski, “Cyber Reconnaissance, Surveillance and Defense”, 1st Edition, Kindle Edition, Syngress; 2014.
5. Michael Sikorski, Andrew Honig, “Practical Malware Analysis: The Hands-On Guide to Dissecting Malicious Software”, Format: Kindle Edition.

ADDITIONAL BOOKS RECOMMENDED

1. Dafydd Stuttard and Marcus Pinto, “The Web Application Hacker's Handbook: Finding and Exploiting Security Flaws”.

Course Outcomes
At the end of the course, students will

CO1	have a knowledge of the basic concepts of network, host, services and vulnerability gathering techniques employed by an attacker.
CO2	be able to use the tools for doing network foot printing including stealth scanning.
CO3	be able to analyze the installations for the vulnerabilities that could be exploited by an adversary.
CO4	be able to extend the existing tools for network and systems protection.
CO5	be able to design the secure system installations that can withstand the adversarial attacks.

M.Tech-I (CSE) Semester – II	**L**	**T**	**P**	**C**
CSCS178: MACHINE LEARNING (INSTITUTE ELECTIVE)	**3**	**0**	**2**	**4**

Course Objective	
1	To understand the basic concepts, state-of-the art techniques of machine learning, statistical analysis and discriminant functions
2	To apply different concepts for the machine learning problems
3	To apply and analyze different supervised and unsupervised learning approaches as per the suitability of the problem
4	To understand and evaluate machine learning methods to use them
5	To design solution of problem using different machine learning approaches

INTRODUCTION	**(05 Hours)**
Pattern Representation, Concept of Pattern Recognition, Basics of Probability, Bayes' Decision Theory, Maximum-Likelihood and Bayesian Parameter Estimation, Error Probabilities, Learning of Patterns, Modeling, Regression, Discriminant Functions, Linear Discriminant Functions, Decision surface, Learning Theory, Fisher Discriminant Analysis.	
LINEAR ALGEBRA FOR ML	**(06 Hours)**
SUPERVISED LEARNING ALGORITHMS	**(06 Hours)**
Gradient Descent, Linear Regression, Support Vector Machines, K-Nearest Neighbor, Naïve Bayes, Bayesian Networks, Classification, Decision Trees, ML and MAP Estimates, Overfitting, Regularization, Bayes Classification, Nearest Neighbor Classification, Cross Validation and Attribute Selection, Bayesian Decision Theory, Losses and Risks, Bayesian Networks, Parametric Methods: Gaussian Parameter Estimation, Maximum Likelihood Estimation, Bias and Variance, Bayes' Estimator, Bayesian Estimation, Parametric Classification, Regression, Naive Bayes, Hidden Markov Models, Support Vector Machines, Decision Trees.	
NEURAL NETWORKS AND LEARNING ALGORITHMS	**(06 Hours)**
Artificial Neural Networks, Perceptron, Multilayer Networks, Back Propagation, Deep Neural Networks, Convolutional Neural Networks, Recurrent Neural Networks; Linear Discrimination, Multilayer Perceptrons: Multilayer Perceptrons, Backpropagation Algorithm, Nonlinear Regression, Convergence, Overtraining, Dimensionality Reduction, Gradient Descent, Recurrent Networks, Cross-Validation and Resampling Methods, Bootstrapping.	
UNSUPERVISED LEARNING ALGORITHMS	**(06 Hours)**
Kernel methods, Basic kernels, Types of Kernel, Properties of kernels, Pattern analysis using Eigen decomposition, Principal Component Analysis, Hidden Markov Models, Markov Decision Processes, Nonparametric techniques for density estimation, Parzen-window method.	
MISCELLANEOUS TOPICS	**(06 Hours)**
Dimensionality Measuring Error, Interval Estimation, Hypothesis Testing, Reduction, Feature Selection, Principal Component Analysis, Pattern Analysis using Eigen Decomposition, Principal Component Analysis, Parzen-windows Method, Model Selection and Theory of Generalization, In-sample and Out-of-sample Error, Vapnik-Chervonenkis (VC) Dimension, VC Inequality, VC Analysis.	
APPLICATIONS	**(10 Hours)**

Signal Processing, Image Processing, Biometric Recognition, Face and Speech Recognition, Information Retrieval, Natural Language Processing.	
Practical Assignments will be based on the coverage of above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED

1. Richard O. Duda, Peter E. Hart, David G. Stork, "Pattern Classification", 2nd Edition, Wiley, 2001.
2. Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.
3. Geoff Dougherty, "Pattern recognition and classification an Introduction", Springer, 2013.
4. Richard O. Duda and Peter E. Hart, "Pattern Classification and Scene Analysis", John Wiley & Sons, 1973.
5. John Shae Taylor and NelloCristianini, "Kernel methods for pattern analysis" Cambridge university press, 2004.

ADDITIONAL BOOKS RECOMMENDED

1. RanjjanShinghal, "Pattern Recognition techniques and application", Oxford university press, 2006.
2. Theodoridis and K.Koutroumbas, "Pattern Recognition", 4th Edition, Academic Press, 2009.

Course Outcomes **At the end of course, students will**	
CO1	have knowledge of pattern recognition, regression, classification, clustering algorithms and statistics.
CO2	be able to apply different feature extraction, classification, regression, neural network algorithms and modeling.
CO3	be able to analyze the data patterns and modeling for applying the learning algorithms and non-parametric approaches.
CO4	be able to evaluate the performance of an algorithm and comparison of different learning techniques.
CO5	be able to design solution for real life problems like biometric recognition, natural language processing and its related applications using various tools and techniques of machine learning.

M. Tech.

Computer Science and Engineering

(CSE)

with specialization in

Data Science

Curriculum and Syllabus

Department of Computer Science and Engineering
M.Tech. Computer Science and Engineering with specialization in Data Science

Sr. No.	Subject	Code	Scheme L-T-P	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
				Th. Marks	T Marks	P Marks		
	First Semester							
1	Mathematical Foundations of Data Science (Core – 1)	CSDS101	3-1-0	100	25	0	4	70
2	Design and Analysis of Algorithms (Core – 2)	CSDS103	3-0-2	100	0	50	4	85
3	Machine Learning (Core – 3)	CSDS105	3-0-2	100	0	50	4	85
4	Core Elective -1	CSDS1XX	3-1-0 / 3-0-2	100	0 / 25	0 / 50	4	70 / 85
5	Core Elective - 2	CSDS1XX	3-0-2	100	0	50	4	85
						Total	**20**	**395 - 410**
6	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	CSDSV91 CSDSP93	0-0-10				5	200 (20 x 10)
	Second Semester							
1	Advanced Statistical Techniques (Core – 4)	CSDS102	3-1-0	100	25	0	4	70
2	Scalable Systems for Data Science (Core – 5)	CSDS104	3-0-2	100	0	50	4	85
3	Elective -3	CSDS1XX	3-1-0 / 3-0-2	100	0 / 25	0 / 50	4	70 / 85
4	Elective -4	CSDS1XX	3-0-2	100	0	50	4	85
5	Institute Elective*	CSDS1XX	3-0-0 / 3-0-2 / 3-1-0	100	0 / 25	0 / 50	3 / 4	55 / 70 / 85
6	Mini Project	CSDS1XX	0-0-4	-	-	100	2	70
						Total	**21 – 22**	**435 - 480**
7	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	CSDSV92 CSDSP94	0-0-10				5	200 (20 x 10)
	Third Semester							
1	MOOC course – I*	Φ	-	-	-	-	3 / 4	70 / 80
2	MOOC course – II*	Φ	-	-	-	-	3 / 4	70 / 80
3	Dissertation Preliminaries	CSDS295	-	-	-	$350^{\$}$	14	560
						Total	**20 - 22**	**700 - 720**
	Fourth Semester							
1	Dissertation	CSDS296	-	-	-	$600^{\$}$	20	800
						Total	**20**	**800**

L: Lecture; T: Tutorial; P: Practical; Th: Theory
***to be offered to the PG students of other department and other PG Programs with the department.**
Subject Code: Core, Electives, Dissertation Preliminary and Dissertation: **$$##nXX;** Vocational Training: **$$##VXX;** Professional Experience: **$$##PXX; $$:** Department Name; ##: M.Tech Course Identity; **n**: Year; **XX**: Core (01 to 10), Elective (11 to 70), Institute Elective (71 to 90), Vocational Training (91 to 92), Professional Experience (93 to 94), Dissertation Preliminary (95), Dissertation (96), XX last digit odd number (for odd semester); XX last digit even number (for even semester)
Calculation of Notional Hours for the subject containing Theory, Tutorial and Practical Example: 3-1-2: 3*15+1*15+2*15+10 (Exam)= 100
$ **Internal**: 40% and **External**: 60%, *Swayam/NPTEL, φ As per 66th IAAC, Dated 20th March, 2024, Resolution No. 66.34 and 61st Senate resolution No. 4, 25th April, 2024.

Code	Elective Subjects	Scheme
	Core Elective 1 and 2	
CSDS111	Foundations of Data Science	3-0-2
CSDS113	Information Retrieval	3-0-2
CSDS115	Advanced Database Management Systems	3-0-2
CSDS117	Embedded Systems Design	3-0-2
CSDS119	Computer Vision and Image Processing	3-0-2
CSDS121	Speech and Audio Processing	3-0-2
CSDS123	High Performance Computing	3-0-2
CSDS125	Research Methodology in CSE	3-1-0
	Core Elective 3 and 4	
CSDS112	Artificial Intelligence	3-0-2
CSDS114	Data Mining and Data Warehousing	3-0-2
CSDS116	Natural Language Processing	3-0-2
CSDS118	Data Science for Software Engineering	3-0-2
CSDS120	Big Data Analytics and Large Scale Computing	3-0-2
CSDS122	Cyber Physical Systems	3-0-2
CSDS124	Machine Learning for Security	3-0-2
	Institute Elective	
CSDS172	Social Networks	3-0-0
CSDS174	Cyber Laws	3-0-0
CSDS176	Business Data Analytics	3-0-2

M. Tech. – I (CSE) DS Semester – I	L	T	P	C
CSDS101: MATHEMATICAL FOUNDATIONS OF DATA SCIENCE (CORE-1)	**3**	**1**	**0**	**4**

Course Objective	
1	To learn the fundamental concepts of set theory, functions, probability.
2	To enable the students to apply the knowledge of probability in data science applications.
3	To learn different statistical inference procedures, probability distributions and random processes.
4	To enable the student to apply the knowledge of linear algebra and statistical analysis in different fields of data science.
5	To design an efficient solution using linear algebra and statistical methods for real time problems.

INTRODUCTION	**(07 Hours)**
Set Theory, Logic and Proofs, Conditional Propositions, Logical Equivalence, Predicates, Quantifiers, Combinatorics.	
FUNCTIONS AND RELATIONS	**(08 Hours)**
Types of Functions, Recursive Functions, Computable and non-computable Functions, Representations of Relations, Composition and Properties of Relations.	
PROBABILITY AND RANDOM VARIABLES	**(10 Hours)**
Overview of Sample Points and Sample Spaces, Events, Bayes Theorem, Probability Axioms, Joint and Conditional Probability, Random Variables, Discrete and Continuous Random Variables, Random Vectors, Transformation of Continuous Random Variables and Vectors by Deterministic Functions, Density Functions of Transformed Continuous Random Variables and Vectors, Multivariate Random Variables, Moments and Moment Generating Functions, Functions of Random Variables.	
RANDOM PROCESSES	**(10 Hours)**
Random Variable vs. Random Process, Bernoulli Random Process, Binomial Process, Statistical Averages, Ensemble and Time Averages, Weak and Strict Sense Stationarity of a Random Process, Ergodicity, Autocorrelation and Auto Covariance Functions of Random Processes and its Relation to Spectra, Poisson Process, Gaussian Process, Martingale Model and Markov Chains.	
ESTIMATION AND STATISTICAL ANALYSIS	**(10 Hours)**
Estimation of Parameters from Data, Maximum Likelihood Estimation, Maximum a Posterior Estimation, Consistency and Efficiency of Estimators, Stochastic State Estimation and MSE of an Estimator, Estimation of Gaussian Random Vectors, Linear Minimum Mean Square Error Estimation, Hypothesis Testing, Significance Level, Types of Errors: Type-I and Type-II, Significance Test, Chi-Squared, Student-t Test, Normality Test, Cramer-Rao Bound on Estimators, Chebyshev Inequality, Kullback-Leibler Divergence, Applications.	
Tutorial Assignments will be based on the coverage of above topics. (Problem statements will be changed every year and will Be notified on website.)	**(15 Hours)**
(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

BOOKS RECOMMENDED

1. Keneth H. Rosen, “Discrete Mathematics and Its Applications”, McGraw-Hill.
2. Judith L. Gersting, “Mathematical Structure for Computer Science”, W.H. Freeman and Co.
3. Athanasios Papoulis and S. Unnikrishna Pillai, “Probability, Random Variables and Stochastic Processes”, McGraw-Hill.

4. Wilbur B. Davenport, "Probability and Random Processes - an introduction for application scientists and engineers", McGraw-Hill.
5. Sheldon M. Ross, Introduction to Probability Models", Academic Press.

Course Outcomes **At the end of the course, students will**	
CO1	have knowledge of the basic concepts and problems of set theory, predicates and logic.
CO2	be able to use functions, graphs, trees, automata and formal languages for problem solving.
CO3	be able to analyze/interpret quantitative data verbally, graphically, symbolically and numerically.
CO4	be able to evaluate and compare the results using different linear algebraic and statistical techniques.
CO5	be able to use linear algebra for optimization and integrate statistical models for solving real life applications.

M. Tech. – I (CSE) DS Semester – I	L	T	P	C
CSDS103: DESIGN AND ANALYSIS OF ALGORITHMS (CORE-2)	**3**	**0**	**2**	**4**

Course Objective	
1	To understand paradigms and approaches used to analyze and design algorithms and to appreciate the impact of algorithm design in practice.
2	To analyze the worst-case time complexity of an algorithm, asymptotic complexities of different algorithms.
3	To design and prove the correctness of the algorithms using appropriate design technique to solve a given real-world computational problem.
4	To analyze and prove the computational intractability of the algorithms of the hard computational problems.
5	To design sub-optimal solutions for the intractable computational problems using alternate design approaches.

INTRODUCTION	**(02 Hours)**
Review of Basis Concepts in Algorithms, Abstract Machines, Analysis Techniques: Mathematical, Empirical and Asymptotic analysis, Review of the Notations in Asymptotic Analysis, Recurrence Relations and Solving Recurrences, Proof Techniques, Illustrations.	
DIVIDE AND CONQUER APPROACH	**(06 Hours)**
Review of Sorting & Order Statistics, Various Comparison based Sorts Analysis, Medians and Order Statistics, The Union-Find Problem, Counting Inversions, Finding the Closest Pair of Points; Lower Bound on Sorting and Non-comparison based Sorts.	
SEARCHING AN DSET MANIPULATION	**(02 Hours)**
Searching in Static Table Binary Search, Path Lengths in Binary Trees and Applications; Optimality of Binary Search in Worst Case and Average Case; Binary Search Trees, Construction of Optimal Weighted Binary Search Trees; Searching in Dynamic Table, Randomly Grown Binary Search Trees, AVL and (a, b) Trees.	
HASHING	**(02 Hours)**
Basic Ingredients, Analysis of Hashing with Chaining and with Open Addressing; Union-Find Problem: Tree Representation of a Set, Weighted Union and Path Compression-Analysis and Applications.	
GREEDY DESIGN TECHNIQUE	**(06 Hours)**
Review of Basic Greedy Control Abstraction, Activity Selection Problem & Variants, Huffman Coding, Horn Formulas; The Knapsack Problem, Clustering; Minimum-Cost Arborescence; Multi-phase Greedy Algorithms, Graph Algorithms; Graph problems: Graph Searching, BFS, DFS, Shortest First Search Minimum Spanning Trees, Single Source Shortest Paths, Maximum Bipartite Cover Problem, Applications, Topological Sort; Connected and Bi-connected Components; Johnson's Implementation of Prim's algorithm using Priority Queue Data Structures.	
DYNAMIC PROGRAMMING	**(08 Hours)**
The Coin Changing Problem, The Longest Common Subsequence, The 0/1 Knapsack Problem; Memoization; Dynamic Programming over Intervals, Shortest Paths and Distance Vector Protocols; Constructing Optimal Binary Search Trees; Algebraic Problems: Evaluation of Polynomials With or Without Preprocessing; Winograd's and Strassen's Matrix Multiplication Algorithms and Applications to Related Problems, FFT, Simple Lower Bound Results.	
STRING PROCESSING	**(02 Hours)**

String Searching and Pattern Matching, Knuth-Morris-Pratt Algorithm and its Analysis; Probabilistic Algorithms, Motivation.	
BACKTRACKING AND BRANCH & BOUND	**(04 Hours)**
Backtracking, General Method, 8-Queens' Problem, Sum of Subsets Problem, Graph Coloring, Hamiltonian Cycles; Branch and Bound to Solve Combinatorial Optimization Problems.	
NP Theory	**(08 hours)**
Polynomial Time Verification, NP-Completeness & the Search Problems, The Reductions, Dealing with NP-Completeness, Local Search Heuristics, Space Complexity; Selected Topics - Algorithms for String Matching, Amortized Analysis, Bloom Filters & Their Applications.	
PROBABILISTIC ALGORITHMS	**(02 Hours)**
Indicator Random Variables, Four Main Design Categories, Randomization of Deterministic Algorithms, Monte Carlo Algorithms, Las Vegas Algorithms, Numerical Probabilistic Algorithms & Various Candidate Applications.	
APPROXIMATION ALGORITHMS	**(03 Hours)**
Introduction and Motivation for Approximation Algorithms, Greedy and Combinatorial Methods; Scheduling: Multiprocessor Scheduling.	
Practical assignments will be based on the coverage of above topics. (Problem statements will be changed every year and will be notified on website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

List of Practical	
1	Lab assignments based on designing algorithms for trivial computational problems and doing their empirical timing analysis.
2	Lab assignments based on designing algorithms using divide and conquer technique and doing their empirical timing analysis.
3	Lab assignments based on designing algorithms using greedy technique and doing their empirical timing analysis.
4	Lab assignments based on designing algorithms using dynamic programming and doing their empirical timing analysis.
5	Lab assignments based on backtracking & branch bound approach to design algorithms.
6	Lab assignments based on designing Approximation algorithms to solve the hard computational problems.

BOOKS RECOMMENDED

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, "Introduction to Algorithms", The MIT Press.
2. Donald E. Knuth, "The Art of Computer Programming, Vol. 1, Vol. 2 and Vol. 3", Narosa/Addison Wesley, New Delhi/London.
3. Ellis Horowitz, SartajSahni, "Data Structures, Algorithms and Applications in C++", Universities Press/Orient Longman.
4. J. Kleinberg, E. Tardos, "Algorithm Design", Pearson Education.
5. Sara Baase, Allen V. Gelder, "Computer Algorithms", Pearson Education.

ADDITIONAL BOOKS RECOMMENDED

1. K. Mehlhom, "Data Structures and Algorithms, Vol. 1 and Vol. 2", Springer-Verlag, Berlin.
2. A. Borodin and I. Munro, "The Computational Complexity of Algebraic and Numeric Problems", American Elsevier, New York.
3. Winograd, "The Arithmetic Complexity of Computation", SIAM, New York.

Course Outcomes At the end of the course, students will	
CO1	have knowledge about the application of mathematical formula/technique to solve the computational problem.
CO2	be able to understand, identify and apply the most appropriate algorithm design technique required to solve a given problem.
CO3	be able to analyze and compare the asymptotic time and space complexities of algorithms.
CO4	be able to write rigorous correctness proofs or implementation for algorithms.
CO5	be able to design and give the solution using innovate/synthesize algorithms to solve the computational problems.

M. Tech. – I (CSE) DS Semester – I	L	T	P	C
CSDS105: MACHINE LEARNING (CORE-3)	**3**	**0**	**2**	**4**

Course Objective	
1	To understand the basic concepts, state-of-the art techniques of machine learning, statistical analysis and discriminant functions.
2	To apply different concepts for the machine learning problems.
3	To analyze supervised and unsupervised learning approaches as per the suitability of the problem.
4	To evaluate machine learning methods for performance and usage for different problems.
5	To design solution of problem using different machine learning approaches.

INTRODUCTION	**(05 Hours)**
Pattern Representation, Concept of Pattern Recognition, Basics of Probability, Bayes' Decision Theory, Maximum-Likelihood and Bayesian Parameter Estimation, Error Probabilities, Learning of Patterns, Modeling, Regression, Discriminant Functions, Linear Discriminant Functions, Decision Surface, Learning Theory, Fisher Discriminant Analysis.	
SUPERVISED LEARNING ALGORITHMS	**(07 Hours)**
Gradient Descent, Linear Regression, Support Vector Machines, K-Nearest Neighbor, Naïve Bayes, Bayesian Networks, Classification, Decision Trees, ML and MAP Estimates, Overfitting, Regularization, Bayes Classification, Nearest Neighbor Classification, Cross Validation and Attribute Selection, Bayesian Decision Theory, Losses and Risks, Bayesian Networks, Parametric Methods: Gaussian Parameter Estimation, Maximum Likelihood Estimation, Bias and Variance, Bayes' Estimator, Bayesian Estimation, Parametric Classification, Regression, Naive Bayes, Hidden Markov Models, Support Vector Machines, Decision Trees.	
NEURAL NETWORKS AND LEARNING ALGORITHMS	**(08 Hours)**
Artificial Neural Networks, Perceptron, Multilayer Networks, Back Propagation, Deep Neural Networks, Convolutional Neural Networks, Recurrent Neural Networks; Linear Discrimination, Multilayer Perceptron: Multilayer Perceptron, Backpropagation Algorithm, Nonlinear Regression, Convergence, Overtraining, Dimensionality Reduction, Gradient Descent, Recurrent Networks, Cross-Validation and Resampling Methods, Bootstrapping.	
UNSUPERVISED LEARNING ALGORITHMS	**(07 Hours)**
Nonparametric Methods: Nonparametric Density Estimation, Histogram Estimator, Kernel Methods, Properties of Kernels, Kernel Estimator, K-Nearest Neighbor Estimator, Nonparametric Classification, K-Means Clustering, Gaussian Mixture Models, Learning with Partially Observable Data, Expectation Maximization Algorithm.	
MISCELLANEOUS TOPICS	**(08 Hours)**
Dimensionality Measuring Error, Interval Estimation, Hypothesis Testing, Reduction, Feature Selection, Principal Component Analysis, Pattern Analysis using Eigen Decomposition, Principal Component Analysis, Parzen-windows Method, Model Selection and Theory of Generalization, In-sample and Out-of-sample Error, Vapnik-Chervonenkis (VC) Dimension, VC Inequality, VC Analysis.	
APPLICATIONS	**(10 Hours)**
Signal Processing, Image Processing, Biometric Recognition, Face and Speech Recognition, Information Retrieval, Natural Language Processing.	
Practical and mini-projects will be based on the coverage of the above topics. (Problem	**(30 Hours)**

statements will be changed every year and will be notified on the website.)	
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

List of Practical	
1	Implement classification and regression techniques.
2	Implement clustering and statistical modeling methods.
3	Implement various dimensionality reduction techniques.
4	Implement neural networks and non-parametric techniques.
5	Implement mini-project based on machine learning approaches.

BOOKS RECOMMENDED

1. Richard O. Duda, Peter E. Hart, David G. Stork, “Pattern Classification”, Wiley.
2. Christopher M. Bishop, “Pattern Recognition and Machine Learning”, Springer.
3. Geoff Dougherty, “Pattern recognition and classification an Introduction”, Springer.
4. Richard O. Duda and Peter E. Hart, “Pattern Classification and Scene Analysis”, John Wiley & Sons.
5. John Shae Taylor and Nello Cristianini, “Kernel Methods for Pattern Analysis” Cambridge University Press.

ADDITIONAL BOOKS RECOMMENDED

1. Ranjjan Shinghal, “Pattern Recognition Techniques and Application”, Oxford University Press.
2. Theodoridis and K. Koutroumbas, “Pattern Recognition”, Academic Press.
3. Judith L. Gersting, “Mathematical Structure for Computer Science”, W.H. Freeman and Co.

Course Outcomes **At the end of course, students will**	
CO1	have knowledge of pattern recognition, regression, classification, clustering algorithms and statistics.
CO2	be able to apply different feature extraction, classification, regression, neural network algorithms and modeling.
CO3	be able to analyze the data patterns and modeling for applying the learning algorithms and non-parametric approaches.
CO4	be able to evaluate the performance of an algorithm and comparison of different learning techniques.
CO5	be able to design solutions for real life problems like biometric recognition, natural language processing, and related applications using various tools and techniques of machine learning.

M. Tech. – I (CSE) DS Semester – I	L	T	P	C
CSDS111: FOUNDATIONS OF DATA SCIENCE (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	To understand the fundamentals of data analytics, distributed database, foundational skills in data science, including preparing and working with data; abstracting and modeling.
2	To go from raw data to a deeper understanding of the patterns and learn to store, manage, and analyze unstructured data structures within the data, to support making predictions and decision making.
3	To learn processing large data sets using Hadoop and make predictions using machine learning and statistical methods.
4	To learn computational thinking and skills, various text analysis and stream data analysis techniques including the Python programming language for analyzing and visualizing data.
5	To learn various topics such as statistics, crawling data, data visualization, advanced databases, complex data represented using graphs or high dimensional data and cloud computing, along with a toolkit to use with data.

INTRODUCTION	**(06 hours)**
Overview of Data Science and Big Data, Datafication: Current landscape of Perspectives, Skill Sets needed; Matrices, Matrices to Represent Relations Between Data and Linear Algebraic Operations on Matrices, Approximately Representing Matrices by Decompositions, SVD and PCA; Statistics: Descriptive Statistics: Distributions and Probability, Statistical Inference: Populations and Samples, Statistical Modeling, Fitting a Model, Hypothesis Testing, Introduction to R and Python.	
DATA PREPROCESSING	**(08 hours)**
Types of Data and Representations, Acquiring Data, Crawling, Parsing Data, Data Manipulation, Data Wrangling, Data Cleaning, Data Integration, Data Reduction, Data Transformation, Data Discretization, Distance Metrics, Evaluation of Classification, Methods: Confusion Matrix, Student's T-tests and ROC Curves, Exploratory Data Analysis, Basic Tools: Plots, Graphs and Summary Statistics of EDA, Philosophy of EDA.	
GRAPH	**(09 Hours)**
Different Types of Graphs, Trees, Basic Concepts Isomorphism and Subgraphs, Multi Graphs and Euler Circuits, Hamiltonian Graphs, Chromatic Numbers, Graph and Tree Processing Algorithms, Graph based Applications.	
DATA VISUALIZATION	**(06 hours)**
Data visualization: Basic Principles and Tools, Graph Visualization, Data summaries, Link analysis, Mining of Graph, High Dimensional Clustering, Recommendation Systems.	
PARADIGMS FOR LARGE SCALE DATA PROCESSING	**(08 hours)**
MapReduce, Hadoop System, Software Interfaces, e.g., Hive, Pig, Traditional Warehouses vs. MapReduce Technology, Distributed Databases, Distributed Hash Tables, Near-real-tips Query.	
TEXT ANALYSIS	**(08 hours)**
Data Flattening, Filtering, Chunking, Feature Scaling, Dimensionality Reduction, Nonlinear Futurization, Shingling of Documents, Locality-Sensitive Hashing for Documents, Distance Measures, LSH Families for Other Distance Measures, Collaborative Filtering, Sampling Data in a Stream, Filtering Streams, Counting	

Distinct Elements in a Stream, Moments, Windows, Clustering for Streams.	
Practical will be based on the coverage of the above topics. (Problem statements will be changed every year and will be notified on the website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

List of Practical	
1	Practical related to Hadoop Installation and implementations using artificial data.
2	Introduction to software tools for data analytics science.
3	Practical based on Basic Statistics and Visualization.
4	Practical related to data preprocessing and data preparation for various Data mining processes.
5	Practical related to different SQL and NOSQL databases.
6	Practical based on Classification.
7	Practical based on K-means Clustering.
8	Practical related to Big Text analysis.

BOOKS RECOMMENDED

1. Joel Grus, “Data science from scratch”, O'Reilly Media.
2. Avrim Blum, John Hopcroft, and Ravindran Kannan, “Foundations of Data Science”, Cambridge University Press.
3. Anand Rajaraman and Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press.
4. Peter Bruce, Andrew Bruce, ”Practical Statistics for Data Scientists: 50”, O’Reilly publishing house.
5. Douglas C. Montgomery and George C. Runger, “Applied statistics and probability for engineers”, John Wiley & Sons.

ADDITIONAL BOOKS RECOMMENDED

1. Jiawei Han, Micheline Kamber and Jian Pei, “Data Mining: Concepts and Techniques”, Morgan Kaufmann.
2. Mohammed J. Zaki and Wagner Miera Jr, “Data Mining and Analysis: Fundamental Concepts and Algorithms”, Cambridge University Press.
3. Matt Harrison, “Learning the Pandas Library: Python Tools for Data Munging, Analysis, and Visualization, O'Reilly.
4. Tom White, “Hadoop: The Definitive Guide”, O’Reilly Media.

Course Outcomes **At the end of the course, students will**	
CO1	be able to understand the principles and purposes of data science, and articulate the different dimensions of the area.
CO2	be able to apply various data pre-processing and manipulation techniques including various distributed analysis paradigms using Hadoop and other tools.
CO3	be able to apply basic data mining machine learning techniques to build a classifier or regression model, and predict values for new examples.
CO4	be able interpret various large datasets by applying Data Mining techniques like clustering, filtering, factorization.
CO5	be able to implement and perform advanced statistical analysis to solve complex and large dataset problems for real life applications.

M. Tech. – I (CSE) DS Semester – I	L	T	P	C
CSDS113: INFORMATION RETRIEVAL (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	To understand the basic building blocks of information retrieval systems.
2	To introduce a variety of indexing techniques, retrieval models and ranking algorithms for information retrieval.
3	To provide comprehensive details of evaluation methods used for information retrieval systems.
4	To apply classification and clustering approaches for information retrieval.
5	To introduce the basic concepts of web information retrieval.

INTRODUCTION	**(05 Hours)**
Information Retrieval Problem, Unstructured and Semi-structured Data, Inverted Index, Processing Boolean Queries, Posting Lists and Dictionaries.	
INDEX CONSTRUCTION AND COMPRESSION	**(10 Hours)**
Sort-Based Index Construction, Hardware Basics, Blocked Sort-Based Indexing, Single-Pass In-Memory Indexing, Distributed Indexing, Dynamic Indexing, Other Types of Indexes such as Positional Indexes and N-Gram Indexes, Statistical Properties of Terms: Heaps' Law and Zipf's Law, Dictionary Compression, Postings Compression.	
RETRIEVAL MODELS AND SCORING	**(10 Hours)**
Boolean, Vector Space, Probabilistic and Semantic Modeling, Vector Space Scoring, TF IDF Weighting, Inverse Document Frequency, The Cosine Measure, Efficient Scoring and Ranking in Search Systems, Relevance Feedback and Query Expansion.	
EVALUATION IN INFORMATION RETRIEVAL SYSTEM	**(06 Hours)**
Standard Test Collections, User Happiness, Precision, Recall, F-Measure, Unranked Retrieval Sets and Ranked Retrieval Results Evaluation, Assessing Relevance, System Quality and User Utility: A Broader Perspective.	
TEXT CLASSIFICATION AND CLUSTERING	**(08 Hours)**
Introduction to Text Classification, Naive Bayes Text Classification, Vector Space Classification (Using Hyper planes, Centroids and K Nearest Neighbors), Support Vector Machine Classifiers, Clustering vs Classification, Partitioning Methods, K-Means Clustering, Hierarchical Clustering.	
OTHER TOPICS IN INFORMATION RETRIEVAL	**(06 Hours)**
Web Crawling, Search Engines, Ranking, Link Analysis, Page Rank, XML Retrieval, Semantic Web.	
Practical and mini-projects will be based on the coverage of the above topics.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

List of Practicals (Problem statements will be changed every year and will be notified on the website.)	
1	Implementation of sort-based and single-pass in-memory indexing.
2	Implementation of distributed and dynamic indexing.
3	Implementation of n-gram indexes.
4	Programs to demonstrate boolean retrieval and vector space models.
5	Program to find the similarity between documents.
6	Implementation of naive bayes text classification.

7	Implementation of vector space classification algorithms such as k nearest neighbor.
8	Programs to implement k-means clustering and hierarchical clustering.
9	Implementation of page rank algorithm.
10	Mini project.

BOOKS RECOMMENDED

1. Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, “Introduction to Information Retrieval”, Cambridge University Press.
2. Stefan Buttcher, Charlie Clarke, Gordon Cormack, “Information Retrieval: Implementing and Evaluating Search Engines”, The MIT Press.
3. Bruce Croft, Donald Metzler, Trevor Strohman, “Search Engines: Information Retrieval in Practice”, Pearson Education.
4. Baeza-Yates Ricardo, Berthier Ribeiro-Neto, “Modern Information Retrieval”, Addison-Wesley.
5. Christopher M. Bishop, “Pattern Recognition and Machine Learning”, Springer.

Course Outcomes **At the end of the course, students will**	
CO1	be able to understand different information retrieval models and indexing techniques.
CO2	understand different text compression algorithms and their role in efficient building and storage of inverted indexes.
CO3	know about different evaluation methods used for information retrieval systems.
CO4	be able to understand the application of various classification and clustering techniques for information retrieval systems.
CO5	be able to understand the working of a search engine and the page ranking algorithm.
CO6	know about the basics of XML retrieval and web search.

M. Tech. – I (CSE) DS Semester – I	L	T	P	C
CSDS115: ADVANCED DATABASE MANAGEMENT SYSTEMS (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	Enhanced the knowledge in the areas of database management that go beyond traditional (relational) database management systems.
2	Comprehend the query processing efficient information management for Distributed, Parallel and Object Oriented DBMS.
3	To understand and implement of different data and their database management systems.
4	To enhance the knowledge about variety of data storage and management.
5	To understand storage and management issues of the unstructured data.

DISTRIBUTED DATABASE CONCEPTS	**(06 Hours)**
Overview of client - server architecture and its relationship to distributed databases, Concurrency control Heterogeneity issues, Persistent Programming Languages, Object Identity and its implementation, Clustering, Indexing, Client Server Object Bases, Cache Coherence.	
PARALLEL DATABASES	**(06 Hours)**
Parallel Architectures, performance measures, shared nothing/shared disk/shared memory based architectures, Data partitioning, Intra-operator parallelism, Pipelining, Scheduling, Load balancing	
QUERY PROCESSING	**(06 Hours)**
Index based, cost estimation, Query optimization: algorithms, Online query processing and optimization, XML, DTD, XPath, XML indexing, Adaptive query processing.	
ADVANCED TRANSACTION MODELS	**(06 Hours)**
Savepoints, Sagas, Nested Transactions, Multi Level Transactions. Recovery: Multilevel recovery, Shared disk systems, Distributed systems 2PC, 3PC, replication and hot spares, Data storage, security and privacy Multidimensional K- Anonymity, Data stream management.	
MODELS OF SPATIAL DATA	**(05 Hours)**
Conceptual Data Models for spatial databases (e.g. pictogram enhanced ERDs), Logical data models for spatial databases: raster model (map algebra), vector model, Spatial query languages, Need for spatial operators and relations, SQL3 and ADT. Spatial operators, OGIS queries	
WEB ENABLED APPLICATIONS	**(06 Hours)**
Review of 3-tier architecture - Typical Middle-ware products and their usage. Architectural support for 3 -tier applications: technologies like RPC, CORBA, COM. Web Application server - WAS architecture Concept of Data Cartridges - JAVA/HTML components. WAS	
OBJECT ORIENTED DATABASES	**(05 Hours)**
Notion of abstract data type, object oriented systems, object oriented db design. Expert databases: use of rules of deduction in data bases, recursive rules.	
ADVANCED TOPICS	**(05 Hours)**
No SQL Databases, Unstructured Databases, Couchbase, MangoDB, Cassendra, Redis, Memcached.	
Practical will be based on the coverage of the above topics. (Problem statements will be changed every year and will be notified on the website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

List of Practical	
1	Write queries and analyze the query performances.
2	Implementation of problem having spatial data.
3	Implement the web based application with database connectivity.
4	Implementation of problem using object oriented concept.
5	Analyse the performance of problem using row oriented database vs no SQL databases.
6	Optimization of Distributed Database Queries: as a Mini Project.

BOOKS RECOMMENDED

1. R. Elmasriand S. Navathe, “Fundamentals of Database Systems”, Benjamin- Cummings.
2. AviSilberschatz, Hank Korth, and S. Sudarshan, “Database System Concepts”, McGraw Hill.
3. S. Shekhar and S. Chawla, “Title Spatial Databases: A Tour”, Prentice Hall.
4. Hector Garcia-Molina, Jeff Ullman, and Jennifer Widom, “Database Systems”, Pearson.
5. Mattison, Rob Mattison, "Web Data Warehousing and Knowledge Management", MGH.

Course Outcomes **At end of the course Student will be able to**	
CO1	Understand advanced database techniques for storing a variety of data with various database models.
CO2	To apply various database techniques/functions with Object Oriented approach to design database for real life scenarios.
CO3	Analyse the problem to design database with appropriate database model.
CO4	Evaluate methods of storing, managing and interrogating complex data.
CO5	Implement web application API’s, distributed databases with the integration of various programming languages.

M. Tech. – I (CSE) DS Semester – I	L	T	P	C
CSDS117: EMBEDDED SYSTEMS DESIGN (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	To learn about hardware and software design requirements of embedded systems, the processes, methodologies, fundamental problems, and best practices associated with the development of applications in the context of high-performance embedded computing systems.
2	To study several different styles of processors used in embedded systems, the use of interrupts and inter-process communication, techniques for tuning the performance of a processor, and to optimize embedded CPUs.
3	To understand memory system optimizations and the back end of the compilation process to determine the quality of code.
4	To study the importance of embedded multiprocessors, their architectures, design techniques, methodologies, algorithms, IoT, and its applications.
5	To learn various embedded software development tools and provide in-depth knowledge of scheduling algorithms and middleware architectures for multiprocessors and hardware/software co-design and co-synthesis algorithms.

INTRODUCTION: EMBEDDED HARDWARE	**(04 Hours)**
Introduction to embedded systems Hardware needs; typical and advanced, timing diagrams, memories (RAM, ROM, and EPROM) Tristate devices, Buses, DMA, UART and PLD's Built-ins on the microprocessor, Example applications, Design methodologies, Embedded Systems Design flows, Models of computation, Parallelism and computation, Reliable system design, CE architecture.	
INTERRUPTS	**(04 Hours)**
Interrupts basics ISR; Context saving, shared data problem. Atomic and critical section, Interrupt latency.	
SOFTWARE AND OS	**(04 Hours)**
Survey of software architectures, Round Robin, Function queue scheduling architecture, Use of real time operating system, RTOS, Tasks, Scheduler, Shared data reentrancy, priority inversion, mutex binary semaphore and counting semaphore, Parallel execution mechanisms, Superscalar, SMID and Vector processors, Variable performance CPU architectures, CPU Simulation, Automated CPU Design.	
INTER-PROCESS COMMUNICATION	**(05 Hours)**
Inter task communication, message queue, mailboxes and pipes, timer functions, events Interrupt routines in an RTOS environment.	
EMBEDDED COMPUTING	**(07 Hours)**
Embedded design process, System description formalisms, Instruction sets- CISC and RISC, DSP processors, Embedded computing platform- CPU bus, Memory devices, I/O devices, interfacing, designing with microprocessors, debugging techniques, Hardware accelerators- CPUs and accelerators, Accelerator system design, Embedded system software design using an RTOS Hard real-time and soft real-time system principles, Task division, need of interrupt routines, shared data.	
INTERNET OF THINGS	**(05 Hours)**
Introduction, IoT work flow, IoT Protocols: HTTP, CoAP, MQTT, 6 LoWPAN, building IoT applications.	

TOOLS	**(06 Hours)**
Embedded Software development tools. Host and target systems, cross compilers, linkers, locators for embedded systems. Getting embedded software in to the target system, Debugging techniques like JTAGS, Testing on host machine, Instruction set emulators, logic analyzers In-circuit emulators and monitors.	
NETWORK	**(05 Hours)**
Distributed embedded architectures, Networks for embedded systems, Network-based design, and Internet enabled systems.	
SYSTEM DESIGN TECHNIQUES	**(05 Hours)**
Design methodologies, Requirements analysis, System analysis and architecture design, Quality assurance.	
Practical assignments will be based on the coverage of above topics.	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

List of Practical (Problem statements will be changed every year and will be notified on website.)	
1	Implement experiment based on programming of Embedded boards.
2	Implement experiment based on Embedded OS.
3	Implement RTOS and job scheduler with Embedded systems.
4	Implement Embedded computing algorithm and evaluate the performance using different tools.
5	Implement mini projects based on Embedded systems for real applications.

BOOKS RECOMMENDED

1. Mohamed Ali Mazidi, Janice GillispieMazidi, RolinMcKinlay, “The 8051 Microcontroller and Embedded Systems: Using Assembly and C”, Pearson Education.
2. Raj Kamal, “Embedded Systems-Architecture, Programming and Design”, TMH.
3. Jonathan W. Valvano, “Embedded Microcomputer Systems-Real Time Interfacing”, Thomson Learning.
4. David A. Simon, “An Embedded Software Primer”, Pearson Education.
5. Louis L. Odette, “Intelligent Embedded Systems”, Addison-Wesley.

ADDITIONAL BOOKS RECOMMENDED

1. Wayne Wolf, “High-Performance Embedded Computing: Architectures, Applications, and Methodologies”, Morgan Kaufmann.
2. Larry L Peterson, “Computer Networks: A Systems Approach”, Morgan Kaufmann.
3. Frank Vahid and Tony Givargis, “Embedded System Design: A Unified Hardware/Software Introduction”, John Wiley.
4. Marilyn Wolf, “Computers as Components- Principles of Embedded Computing System Design”, Morgan Kaufmann.
5. Denial D. Gajski, Frank Vahid, “Specification and design Embedded systems”, Prentice Hall; Facsimile edition.

Course Outcomes **At the end of the course, students will**	
CO1	be able to understand hardware-software requirements, interrupts and inter process communication of embedded systems.
CO2	be able to apply techniques for simulating processors, for tuning the performance of a processor and to optimize embedded CPUs, such as code compression and bus encoding. They will be able to use middleware architectures for dynamic resource allocation in multiprocessors
CO3	be able to analyze the embedded systems' specifications and develop software programs.
CO4	be able to evaluate related software architectures and tools for embedded Systems and evaluate the quality of code using the back end of the compilation process and be able to characterize embedded applications and target architectures using different models.
CO5	be able to design and develop real time embedded systems using the concepts of RTOS.

M. Tech. – I (CSE) DS Semester – II	L	T	P	C
CSDS119: COMPUTER VISION AND IMAGE PROCESSING (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	To understand the fundamentals image processing and computer vision about image formation, representation and camera calibration.
2	To study various image processing operations and computer vision techniques for camera calibration, depth, motion, stereo and optical flow estimation.
3	To learn different vision based advanced techniques for image understanding and interpreting the images in spatial and frequency domain.
4	To learn different feature extraction and algorithm evaluation techniques for image analysis.
5	To enable student to develop various applications using image processing and computer vision techniques.

LOW LEVEL IMAGE PROCESSING	**(08 Hours)**
Overview of Image and Vision Applications, Illumination, Sampling and Quantization, Image representation and Modeling, Image sources, Image processing application, Image Enhancement, Contrast, Resolution, Histogram Equalization, Spatial Filters, Frequency Representation and Filters, Edge detection, Canny edge detector, Corner detection, Morphological Operation, Color Image Processing, Human eye and cognitive aspects of color, Color transformation.	
HIGH LEVEL IMAGE PROCESSING	**(09 Hours)**
Order statistic filters, Image Segmentation, Object Boundary Detection and Representation, Texture representation, Gabor filters, Noise Removal, Blurring, Image restoration, Image compression.	
IMAGE FORMATION AND RADIOMETRY	**(06 Hours)**
Basics of Image Formation and Radiometry, Bidirectional Reflection Distribution Function, Reflectance Map, Image Formation and Coordinate Transformations, Camera Pin-hole model, Camera calibration, Camera Parameters: Internal and External, Camera Parameters estimation, 3D coordinates and transformation.	
SHAPE AND MOTION ANALYSIS	**(06 Hours)**
Calculus of variation theory, Light at Surfaces, Phong Model, Albedo estimation, Horn-Schunk Optical Flow Formulation, Motion estimation, Epipolar geometry, Photometric Stereo, Structure from motion, Depth from stereo, Shape from Shading, Surface smoothness, Relaxation methods for depth estimation, Shape from texture, 3-D models, Volumetric representation and modeling, Surface modeling.	
IMAGE ANALYSIS AND UNDERSTANDING	**(09 Hours)**
Multi resolution approach, Super resolution, MRF based modeling, Labelling, MRF based applications: Segmentation, Object recognition, Facial detection, Biometric: Iris and Finger print, Feature extraction, Feature vector dimension Reduction, Template based modeling for recognition, Knowledge representation, Feature matching algorithm.	
APPLICATIONS	**(07 Hours)**
Video summarization, In-painting, Biometric recognition, Target detection and tracking, Face recognition, Human gesture and action recognition, Animated Character, Rendering.	
Practical and mini-projects will be based on the coverage of the above topics.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

List of Practical (Problem Statements will be changed every year and will be notified on Website.)	
1	Implementation of low level, mid-level, and high-level image processing algorithms.
2	Implementation of various filters and transformation techniques for frequency domain operations.
3	Implementation of camera calibration and estimation of internal and external parameters.
4	Implementation of depth using optical flow, stereo and motion.
5	Implementation of application-basedmini-project.

BOOKS RECOMMENDED

1. Rafael C. Gonzales and Richard E. Woods, "Digital Image Processing", 4th edition Education, Reprint 2018.
2. Anil K. Jain, "Fundamentals of Digital Image Processing", PHI, EEE, 4th reprint 2002.
3. David A. Forsyth and Jean Ponce, "Computer Vision: A Modern Approach", Prentice -Hall, 2004.
4. J. R. Parker, " Algorithms for Image Processing and Computer Vision", 2ndedition ,Wiley, 2010.
5. Robert M. Haralick and Linda G. Shapiro, "Computer and Robot Vision ", Addison Wesley, 1992.

ADDITIONAL BOOKS RECOMMENDED

1. Milan Sonka, Vaclav Hlavac, Roger Boyal, “Image Processing Analysis and Machine Vision” 3rdEd. PWS / Thomson Publishing, 2007.
2. Richard Hartley and Andrew Zisserman, “Multiple View Geometry in Computer Vision”, Second Edition, Cambridge University Press, March 2004.

Course Outcomes **At the end of the course, students will**	
CO1	be able to understand fundamentals of image processing and computer vision and image analyzing techniques.
CO2	be able to apply various image processing operations for analyzing images and vision related techniques for segmentation, visualization of depth and camera calibration.
CO3	be able to analyze the problem and effectively use appropriate technique for image processing and vision related problem solving.
CO4	be able to evaluate critically the solutions developed for image processing and vision problems.
CO5	be able to build new applications using advanced image processing and computer vision techniques.

M. Tech. – I (CSE) DS Semester – I	L	T	P	C
CSDS121: SPEECH AND AUDIO PROCESSING (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	To learn the basics of digital signal processing, analytical methods and it's different applications
2	To understand fundamentals of speech
3	To learn different speech models and speech processing
4	To learn the design of different filters in spatial and frequency domain for speech processing
5	To develop skills for analyzing and synthesizing algorithms and systems for speech recognition, identification, classification for different applications.

BASICS OF DIGITAL SIGNAL	**(06 Hours)**
Analog vs. Digital Signal, Continuous vs. Discrete Signal, Issues with Analog signal processing, Digital signal transmission, Overview of different applications, Fundamentals of z-transform, Fourier transform, Overview of Digital filters: FIR and IIR, Sampling theorem, Decimation and Interpolation.	
FUNDAMENTALS OF SPEECH	**(05 Hours)**
Speech signal, Digital representation of speech, Speech production and perception, Acoustic modeling, Acoustic tubes and features, Acoustic phonetics, Sound propagation, Phase vocoder, Channel vocoder, Vocal tract functioning, Vocal tract transfer function, Time domain models, Frequency domain representation, Concepts of Subband.	
TIME DOMAIN ANALYSIS	**(08 Hours)**
Short time energy and average magnitude, Short time average zero-crossing rate, Pitch period estimation, Speech and silence discrimination, Short time autocorrelation function, Median smoothing, Quantization, Companding, Adaptive Quantization, Delta modulation, Differential PCM.	
FREQUENCY DOMAIN ANALYSIS	**(10 Hours)**
Short time Fourier representation, Short time analysis, Spectrographic, Spectrum analysis, Complex Cepstrum, Pitch Detection, Formant estimation, Linear predictive analysis, LPC equation, solutions, Frequency domain interpretation of Linear Predictive analysis, Relations between various speech parameters, Applications of LPC parameters, IIR and FIR filters design.	
SPEECH MODELING AND PROCESSING	**(16 Hours)**
Vocabulary, Language Modeling, Hidden Markov Models, Pattern Classification and Recognition, Speech Compression, Speech synthesis, Speech recognition, Speaker identification, Emotion analysis, Language identification, Speech Conversion, Speech processing using Neural Networks, Deep Learning.	
Practical and mini-projects will be based on the coverage of the above topics.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

List of Practical (Problem statements will be changed every year and will be notified on website.)	
1	Implementation of basic signal transforms like Fourier, Wavelet and others.
2	Implementation of preliminary feature extractions from speech signals.
3	Implementation of time domain analysis techniques and design of different filters.
4	Implementation of frequency domain analysis techniques and design of different filters.
5	Implementation of advanced techniques of modelling for speech processing.
6	Implementation of application based mini project.

BOOKS RECOMMENDED

1. Lawrence R. Rabiner and Ronald W. Schafer, “Theory and Applications of Digital Signal Processing”, Pearson.
2. Lawrence R. Rabiner and Ronald W. Schafer, “Digital Processing of Speech Signals”, Pearson.
3. Lawrence Rabiner, Biing-Hwang Juang, B. Yegnanarayana, “Fundamentals of Speech Recognition”, Pearson.
4. Douglas O’Shaughnessy, “Speech Communications Human and Machines”, Institute of Electrical and Electronics Engineers.
5. Ben Gold and Nelson Morgan, “Speech and Audio Signal Processing”, Wiley.

ADDITIONAL BOOKS RECOMMENDED

1. M. R. Schroeder, “Computer Speech: Recognition, Compression, Synthesis”, Springer Series in Information Science.

Course Outcomes **At the end of the course, students will**	
CO1	be able to understand the process of converting the continuous-time signal into digital signal, process it and convert back to continuous-time signal
CO2	be able to apply the different digital filters to design speech processing applications
CO3	be able to analyse the speech in time domain and frequency domain and also able to analyse tools like Fourier transform and z-transform to find a system's frequency response or system's impulse response
CO4	be able to evaluating the performance of a speech processing based systems like speech recognition, speech identification and many more
CO5	be able to design robust and efficient the speech models and speech processing systems

M. Tech. – I (CSE) DS Semester – I	L	T	P	C
CSDS123: HIGH PERFORMANCE COMPUTING (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	To understand fundamentals concepts related to High-Performance Computing and state-of-the-art in Parallel Programming environment
2	To study the architectures of several types of high-performance computers and the implications on the performance of algorithms of these architectures
3	To provide an in-depth analysis of design issues in parallel computing
4	To learn the programming constructs required for parallel programming
5	To learn how to achieve parallelism in CUDA architectures

Parallel Processing Concepts	**(10 Hours)**
Levels of parallelism (instruction, transaction, task, thread, memory, function), Models (SIMD, MIMD, SIMT, SPMD, Dataflow Models, and Demand-driven Computation etc.), Architectures: N-wide superscalar architectures, multi-core, multi-threaded, performance file systems, GPU systems, performance clusters.	
Design Issues and challenges in Parallel Computing	**(10 Hours)**
Synchronization, Scheduling, Job Allocation, Job Partitioning, Dependency Analysis, Mapping Parallel Algorithms onto Parallel Architectures, Performance Analysis of Parallel Algorithms, Bandwidth Limitations, Latency Limitations, Latency Hiding/Tolerating Techniques and their limitations, Power-Aware Computing and Communication, Power-aware Processing Techniques, Power-aware Memory Design, Power-aware Interconnect Design, Software Power Management.	
Parallel Programming with OpenMP and mpi	**(10 Hours)**
Programming languages and programming-language extensions for HPC, Inter-process communication, Synchronization, Mutual exclusion, Basics of parallel architecture, Parallel programming with OpenMP and (Posix) threads, Message passing with MPI, Thread Management, Workload Manager, Job Schedulers.	
Parallel Programming with CUDA	**(10 Hours)**
Processor Architecture, Interconnect, Communication, Memory Organization, and Programming Models in high-performance computing architectures: (Examples: IBM CELL BE, Nvidia Tesla GPU, Intel Larrabee Micro architecture and Intel Nehalem micro architecture), Memory hierarchy and transaction-specific memory design, Thread Organization, OpenCL.	
Advanced Topics	**(05 Hours)**
Peta scale Computing, Optics in Parallel Computing, Quantum Computers.	
Practical and mini-projects will be based on the coverage of the above topics.	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

List of Practical (Problem statements will be changed every year and will be notified on website.)	
1	Implement parallel programming preliminary examples.
2	Implement algorithms using OpenMP and MPI.

3	Implement experiments using CUDA.
4	Implement and evaluate performance HPC algorithms for load distribution, thread management and job scheduling.
5	Implementation of mini-projects in different areas.

BOOKS RECOMMENDED

1. John L. Hennessy and David A. Patterson “Computer Architecture -- A Quantitative Approach”, 4th Ed., Morgan Kaufmann Publishers.
2. Barbara Chapman, Gabriele Jost and Ruud van der Pas, “Using OpenMP: portable shared memory parallel programming”, The MIT Press.
3. Marc Snir, Jack Dongarra, Janusz S. Kowalik, Steven Huss-Lederman, Steve W. Otto, David W. Walker, “MPI: The Complete Reference”, Volume2, The MIT Press.
4. Pacheco S. Peter, “Parallel Programming with MPI”, Morgan Kaufman Publishers.
5. Shane Cook, CUDA Programming: A Developer's Guide to Parallel Computing with GPUs, Morgan Kaufmann publishers.

Course Outcomes **At the end of the course, students will**	
CO1	be able to learn concepts, issues and limitations related to parallel computing.
CO2	be able to understand and explain different parallel models of computation, parallel architectures, interconnections and various memory organizations in modern high-performance architectures.
CO3	be able to map algorithms onto parallel architectures for parallelism.
CO4	be able to analyze and evaluate the performance of different architectures and parallel algorithms.
CO5	be able to design and implement parallel programs for shared-memory architectures and distributed-memory architectures using modern tools like OpenMP and MPI, respectively.

M. Tech. – I (CSE) DS Semester – I	L	T	P	C
CSDS125: RESEARCH METHODOLOGY IN CSE (CORE ELECTIVE-1 OR 2)	**3**	**1**	**0**	**4**

Course Objective	
1	To understand the basic terminology of research, its methodology and learn different methodologies of pursuing the research in terms of organization, presentation and evaluation.
2	To apply the concept in writing the technical content.
3	To analyze the existing method using different parameters in different scenarios.
4	To evaluate the proposed work and compare with existing approach systematically using the appropriate methodology, through simulation depending upon the research field.
5	To design algorithms using concepts learned and write report and papers technically and grammatically correct.

INTRODUCTION	**(04 Hours)**
Research: Definition, Characteristics, Motivation and Objectives, Research Methods vs Methodology, Types of Research – Descriptive vs Analytical, Applied vs Fundamental, Quantitative vs Qualitative, Conceptual vs Empirical.	
METHODOLOGY	**(04 Hours)**
Research Process, Formulating the Research Problem, Defining the Research Problem, Research Questions, Research Methods vs. Research Methodology.	
LITERATURE REVIEW	**(04 Hours)**
Review Concepts and Theories, Identifying and Analyzing the Limitations of Different Approaches.	
FORMULATION AND DESIGN	**(05 Hours)**
Concept and Importance in Research, Features of a Good Research Design, Exploratory Research Design, Concept, Types and Uses, Descriptive Research Designs, Concept, Types and Uses, Experimental Design: Concept of Independent & Dependent Variables.	
DATA MODELING AND SIMULATIONS	**(08 Hours)**
Mathematical Modeling, Experimental Skills, Simulation Skills, Data Analysis and Interpretation.	
TECHNICAL WRITING AND TECHNICAL PRESENTATIONS	**(05 Hours)**
CREATIVITY AND ETHICS IN RESEARCH, INTELLECTUAL PROPERTY RIGHTS	**(05 Hours)**
TOOLS AND TECHNIQUES FOR RESEARCH	**(06 Hours)**
Methods to Search Required Information Effectively, Reference Management Software, Software for Paper Formatting, Software for Detection of Plagiarism.	
DISCUSSION AND DEMONSTRATION OF BEST PRACTICES	**(04 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)

BOOKS RECOMMENDED
1. John W. Creswell, "Research Design: Qualitative, Quantitative, and Mixed Methods Approaches", SAGE Publications Ltd. 2. C.R. Kothari, "Research Methodology: Methods and Techniques", New Age International Publishers. 3. David Silverman, "Qualitative Research", SAGE Publications Ltd. 4. Norman K. Denzin and Yvonna Sessions Lincoln, "Handbook of Qualitative Research", SAGE Publications Ltd. 5. Michael Quinn Patton, "Qualitative Research and Evaluation Methods", SAGE Publications Ltd.

Course Outcomes **At the end of the course, students will**	
CO1	have an understanding of the different research methodology in different areas.
CO2	be able to apply the concepts in writing, presentation, and simulating different experiments.
CO3	be able to analyze the proposed work with existing approaches in the literature and interpret the research design through project development and case study analysis using appropriate tools.
CO4	be able to execute the technical presentation, organization in writing the report and papers.
CO5	be able to design the algorithms and proof learned and communicate effectively through proper organization and presentation.

M. Tech. – I (CSE) DS Semester – II	L	T	P	C
CSDS102: ADVANCED STATISTICAL TECHNIQUES (CORE-4)	**3**	**1**	**0**	**4**

Course Objective	
1	To regain/replenish understanding core principles of statistical hypothesis testing (NHST) and techniques.
2	To use statistical principles to describe and comprehend data, including how it represents the real world and how it does not.
3	To test hypotheses or make predictions, use statistical approaches to data.
4	To create and implement analyses that result in new knowledge, decisions, and actions.
5	To communicate quantitative analysis results, conclusions and learn from and criticize the statistical analyses of others.

INTRODUCTION	**(05 Hours)**
Overview of Statistical Learning, Applications: Wage Data, Stock Market Data, Gene Expression Data, History, Statistical Learning Tools, Multivariate Approaches, Inference and Interpreting the Results of Analysis.	
STATISTICAL LEARNING	**(06 Hours)**
Statistical Learning Methods, Assessing Model Accuracy, Comparing Several Means: Analysis of Variance (ANOVA), Analysis of Covariance, Introduction to R, One-way ANOVA.	
LINEAR REGRESSION AND CLASSIFICATION	**(06 Hours)**
Simple Linear Regression, Multiple Linear Regression, Other Considerations in the Regression Model, The Marketing Plan, Comparison of Linear Regression with K-Nearest Neighbours, Logistic regression, Linear Discriminant Analysis, Quadratic Discriminant Analysis, Path analysis.	
RESAMPLING METHODS	**(05 Hours)**
Bootstrapping, Cross validation, Subset Selection, Best-Subset Selection, Forward Stepwise Selection, Backward Stepwise Selection, Hybrid Methods, Dimension Reduction Methods.	
LINEAR MODEL SELECTION, REGULARIZATION AND MOVING BEYOND LINEARITY	**(08 Hours)**
PCR and PLS Regression, Polynomial Regression, Step Functions, Basis Functions, Regression Splines, Generalized Additive Models, Nonlinear Models, Factor Analysis, Multidimensional Scaling, Non-parametric techniques, Shrinkage, Ridge regression.	
TREE BASED METHODS, SUPPORT VECTOR MACHINES AND UNSUPERVISED	**(05 Hours)**
Basics of Decision Trees, Bagging, Random Forests, Boosting, Maximal Margin Classifier, Support Vector Classifiers, Unsupervised Learning, Principal Components Analysis, Clustering Methods.	
ADVANCED TOPICS	**(10 Hours)**
Collaborative Filtering, Pattern Matching, Geostatistical Analysis, Statistics in Medicine, Environmental Statistics and Causality Analysis, Efficient Statistical Sample Design	
Practical assignments will be based on the coverage of above topics.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

List of Practical (Problem statements will be changed every year and will be notified on website.)	
1	Introduction to R, One-way ANOVA.
2	Logistic Regression, LDA, QDA, and KNN.

3	Cross-Validation and the Bootstrap
4	Non-linear Modeling.
5	Decision Trees, Lab: Support Vector Machines, Lab: PCA, Clustering, NCI60 Data Example.
6	Hands on with deep neural models.

BOOKS RECOMMENDED

1. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, “An introduction to statistical learning” Springer.
2. Friedman, Jerome, Trevor Hastie, and Robert Tibshirani, “The elements of statistical learning”, Springer.
3. Hadley Wickham and Garrett Grolemund, "R for data science", Shroff/O'Reilly.
4. Piegorsch W. Walter, “Statistical Data Analytics”, John Wiley and Sons Ltd.
5. Richard Golden, “Statistical Machine Learning A Unified Framework”, Taylor and Francis.

Course Outcomes **At the end of the course, students will**	
CO1	become familiar with several statistical analysis techniques.
CO2	be able to understand and analyze data in applied settings, he /she must be able to assess the appropriateness of statistical analyses, outcomes, and inferences.
CO3	be able to choose the appropriate analytical methodology for fresh research and evaluate the results accurately.
CO4	be able to learn about canonical examples of linear models to relate them to techniques and applications.
CO5	be able to conduct statistical analyses using SPDS.

M. Tech. – I (CSE) DS Semester – II	L	T	P	C
CSDS104: SCALABLE SYSTEMS FOR DATA SCIENCE (CORE-5)	**3**	**0**	**2**	**4**

Course Objective	
1	To understand the basic concepts and technologies of scalable distributed systems.
2	To apply the different scalable distributed system designs for solving real application problems.
3	To analyze how distributed program models such as MapReduce, TensorFlow, Vertex-centric and streaming data flows are designed to analyze large datasets.
4	To execute and compare the different popular Big Data and ML platforms like HDFS, Spark, MLLib, TensorFlow, Cassandra, Flink, etc. and understand how they are architected.
5	To develop distributed algorithms and scalable analytics applications using various design patterns.

INTRODUCTION	**(04 Hours)**
Revision of Data Structures, Arrays, Queues, Trees, Hash Maps, Graphs; Sorting Algorithms, Searching Techniques, Traversal Methods, Data Mining Basics, Statistical Limits on Data Mining.	
MEMORY-EFFICIENT DATA STRUCTURES AND APPROXIMATION	**(04 Hours)**
Memory-Efficient Data Structures, Hash Functions, Universal / Perfect Hash Families, Bloom Filters, Sketches for Distinct Count, Misra-Gries Sketch, Count Sketch, Count-Min Sketch, Approximate Near Neighbors Search, KD-Trees, LSH Families, MinHash for Jaccard, SimHash for L2, Multi-Probe, B-Bit Hashing, Data Dependent Variants, Randomized Numerical Linear Algebra, Random Projection.	
MACHINE LEARNING HARDWARE SYSTEMS	**(05 Hours)**
Machine Learning Hardware Systems, Issues, Heterogeneous Hardware Accelerators' Architecture and Accelerated Computing: Tensor Processing Units, Graphics Processing Unit.	
VIRTUAL MACHINES AND VIRTUALIZATION OF CLUSTERS AND DATA CENTRES	**(06 Hours)**
Levels of Virtualization Implementation, Design Requirements and Providers, Virtualization Support: at the OS Level and Middleware, Virtualization Tools, Hypervisor and Xen Architecture, Binary Translation with Full Virtualization, Para-Virtualization with Compiler Support, Hardware Support for Virtualization, CPU Virtualization, Memory Virtualization, I/O Virtualization, Virtualization in Multi-Core Processors, Virtual Clusters and Resource Management, Physical versus Virtual Clusters, Live VM Migration Steps and Performance Effects, Migration of Memory, Files, and Network Resources, Dynamic Deployment of Virtual Clusters.	

MAPREDUCE AND THE NEW SOFTWARE STACK	**(05 Hours)**
Distributed File Systems, MapReduce, Algorithms using MapReduce, Extensions to MapReduce, Communication Cost Model, Complexity Theory for MapReduce.	
ANALYZING BIG DATA	**(08 Hours)**
Challenges of Data Science, Introduction of Apache Spark, Data Analysis with Scala and Spark, Spark Programming Model, Record Linkage, Getting Started: The Spark Shell and Spark Context, Bringing Data from the Cluster to the Client, Shipping Code from the Client to the Cluster, Structuring Data with Tuples and Case Classes, Aggregations, Creating Histograms, Summary Statistics for Continuous Variables, Creating Reusable Code for Computing Summary Statistics, Simple Variable Selection and Scoring.	
DISTRIBUTED MACHINE LEARNING AND OPTIMIZATION	**(05 hours)**
Spark MLLib for Machine Learning: ML Algorithms, Featurization, Pipelines, Persistence, Utilities. TensorFlow	

for Deep Learning: Parameter Server, Federated, Alternating Direction Method of Multipliers and Applications, Clustering.	
NOSQL DATABASES AND LINKED DATA ANALYSIS	**(04 Hours)**
Consistency Models and CAP Theorem/BASE, Amazon Dynamo/Cassandra Distributed Key-Value Store, Google Big Table/HBase and SparkSQL for SQL-like Querying, Mining Social-Network Graphs, Social Networks as Graphs, Partitioning of Graphs, Finding Overlapping Communities, Simrank, Neighborhood Properties of Graphs, NOSQL Database.	
MANAGED SERVICES	**(04 Hours)**
Introduction to Cloud Computing, Cloud Strategy, Cloud Native Development, Container Adoptions, Application Modernization, Distributed App Coordination, Event Routing, Messaging, Service Discovery, Service Mesh, Workflow Orchestration, AWS, Azure.	
Practical assignments will be based on the coverage of above topics.	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

List of Practical (Problem statements will be changed every year and will be notified on website.)	
1	Installation and setup of different tools mentioned in the classroom session like spark, Hadoop, HDFS, MLLib, TensorFlow, Cassandra, Flink.
2	Federated learning using edge computing and cloud computing resources, Distributed edge.
3	Experimenting with cloud storage and querying systems, Scalable querying over knowledge graphs, Scalable training and differencing over graph neural networks.
4	Experiment using Scalable pattern mining and analysis over Twitter streams.
5	Experiment using NoSQL database and application development using AWS, Azure.

BOOKS RECOMMENDED

1. Jure Leskovec, Anand Rajaraman, Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press.
2. S. Muthukrishnan, “Data streams: Algorithms and Applications (Foundations and Trends® in Theoretical Computer Science), now Publishers Inc, USA.
3. Michael W. Mahoney, “Randomized algorithms for matrices and data: 9 (Foundations and Trends® in Machine Learning), now Publishers, USA.
4. Jimmy Lin, Chris Dyer, “Data-Intensive Text Processing with Map Reduce”, Morgan & Claypool Publishers.
5. Sandy Ryza, Uri Laserson, Josh Wills, Sean Owen, “Advanced Analytics with Spark”, O'Reilly Media Publisher.

ADDITIONAL BOOKS RECOMMENDED

1. Woodruff P. David, “Sketching as a Tool for Numerical Linear Algebra”, Foundations and Trends® in Theoretical Computer Science, now Publishers, USA.

Course Outcomes **At the end of the course, students will**	
CO1	have knowledge for types of Big Data, Design goals of Big Data platforms, and where in the systems landscape these platforms fall.
CO2	have information about distributed programming models for Big Data, including Map Reduce, Stream processing and Graph processing.
CO3	have learned runtime Systems for Big Data platforms and their optimizations on commodity clusters and Clouds.

CO4	be familiar with scaling data Science algorithms and analytics using Big Data platforms.
CO5	be able to configure, use different data mining software tools and develop applications to achieve scalable systems.

M. Tech. – I (CSE) DS Semester – II	**L**	**T**	**P**	**C**
CSDS112: ARTIFICIAL INTELLIGENCE (CORE ELECTIVE-3 OR 4)	**3**	**0**	**2**	**4**

Course Objective	
1	To introduce the basic concepts of Artificial Intelligence (AI), with illustrations of current state of the art research, tools and applications.
2	To understand the basic areas of AI including problem solving, knowledge representation, heuristic, reasoning, decision making, planning and statistical methods.
3	To identify the type of an AI problem and apply it for search inference, decision making under uncertainty, game theory etc.
4	To describe the knowledge representation techniques, strengths and limitations of various state-space search algorithms, and choose the appropriate algorithm.
5	To introduce advanced topics of AI such as planning, Bayes networks, natural language processing and Expert systems.

INTRODUCTION TO AI AND INTELLIGENT AGENTS	**(05 Hours)**
Basic concepts of Intelligence, Scope and View of AI, Applications of AI, Turing Test, Intelligent Behavior, Intelligent Agents, AI Techniques, AI-Problem formulation, AI Applications, Production Systems, Control Strategies.	
PROBLEM SOLVING	**(08 Hours)**
Defining the problems as a State Space Search and Production Systems, Production Characteristics, Production System Characteristics, And issues in the Design of Search Programs, Additional Problems. Informed and uninformed search strategies: Generate-And-Test, Breadth first search, Depth first search, Hill climbing, Best first search, A* algorithm, AO* Algorithm, Iterative Deepening Search, IDA*, Recursive Best First Search, Constraint propagation, Neural, Stochastic, and Evolutionary search algorithms, Constraint Satisfaction and Heuristic Repair, Applications.	
KNOWLEDGE REPRESENTATION AND REASONING	**(07 Hours)**
Knowledge representation - Production based system, Frame based system, Knowledge representation using Predicate logic, Introduction to predicate calculus, Rule based representations, Declarative / Logical formalisms, Knowledge bases and Inference, Reasoning in uncertain environments, Logic-Structured based Knowledge representation, Inference – Backward chaining, Forward chaining, Rule value approach, Fuzzy reasoning – Certainty factors, Bayesian Theory-Bayesian Network-Dempster – Shafer theory, Symbolic Logic under Uncertainty : Non-monotonic Reasoning, Logics for non-monotonic reasoning, Statistical Reasoning : Probability and Bayes Theorem, Certainty factors, Probabilistic Graphical Models, Bayesian Networks, Markov Networks.	
GAME PLAYING AND PLANNING	**(07 Hours)**
Introduction, Example Domain: Overview, MiniMax, Alpha-Beta Cut-off, Refinements, Iterative deepening, The Blocks World, Components of a Planning System, Goal Stack Planning, Nonlinear Planning Using Constraint Posting, Hierarchical Planning, Reactive Systems, Other Planning Techniques, Recent applications.	
MULTI GAME THEORY	**(08 Hours)**

Introduction, Behavioral game theory: Dictator, Ultimatum and trust games, Mixed strategy equilibrium, Bargaining, Dominant solvable games, Coordination games, Signaling and reputation, Types of learning Reinforcement, Belief, Imitation, Stochastic game theory, Evolutionary games and Markov games for multi-agent reinforcement learning, Economic Reasoning and Artificial Intelligence, Designing games: Cooperative games, Voting, Auctions, Elicitation, Scoring rules, Decision Making and Utility Theory, Adaptive decision making, Analyzing games: Combinatorial games, Zero-sum games, General-sum games, Nash Equilibrium, Correlated Equilibrium, Price of anarchy.	
EXPERT SYSTEMS	**(10 Hours)**
Expert Systems – Architecture of Expert Systems, Roles of Expert Systems – Knowledge Acquisition – Meta Knowledge, Heuristics, Typical Expert Systems – MYCIN, DART, XOON, Expert Systems Shells.	
Practical assignments will be based on the coverage of above topics.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

List of Practical (Problem statements will be changed every year and will be notified on website.)	
1	Introduction to PROLOG programming.
2	Implement Informed and uniformed based search techniques.
3	Implement various algorithms based on game theory.
4	Practical based on fuzzy logic-based application.
5	Practical based on statistical methods.
6	Implement an expert system for real applications.
7	Practical based on multilayer perceptron.
8	Implement neural network-based application

BOOKS RECOMMENDED

1. Stuart Russell and Peter Norvig, “Artificial Intelligence: A Modern Approach”, Prentice-Hall.
2. Nils J. Nilsson, “Artificial Intelligence: A New Synthesis”, Morgan-Kaufmann.
3. Elaine Rich and Kevin Knight, “Artificial Intelligence”, Tata McGraw-Hill.
4. W. Patterson, ‘Introduction to Artificial Intelligence and Expert Systems’, Prentice Hall of India.
5. I. Bratko, "Prolog Programming for Artificial Intelligence", Addison-Wesley.

ADDITIONAL BOOKS RECOMMENDED

1. Donald A. Waterman, “A Guide to Expert Systems”, Pearson Education.
2. David Poole, Alan Mackworth, Artificial Intelligence: Foundations for Computational Agents, Cambridge Univ. Press.
3. J. Han and M. Kamber, Mining: Data Concepts and Techniques, 3rd Edition, Morgan Kaufman.
4. Hastie, Tibshirani, Friedman, “The elements of statistical learning”, second edition, Springer.

Course Outcomes **At the end of the course, students will**	
CO1	be able to understand foundational principles, mathematical tools, program paradigms and fundamental issues, challenges of artificial intelligence, formal methods of knowledge representation, logic and reasoning.
CO2	be able to apply intelligent agents for artificial intelligence programming techniques, Fuzzy logic

	for problem solving and semantic rules for reasoning and inference to real world problems.
CO3	be able to analyze and formalize the problem as a state space, graph, design heuristics and select amongst different search or game-based techniques to solve them.
CO4	be able to evaluate the performance of an informed and uninformed search strategies, fuzzy logic, and expert system and connectionist models based systems.
CO5	be able to design the application on different artificial intelligence techniques like heuristic, game search algorithms, fuzzy, expert system and neural network.

M. Tech. – I (CSE) DS Semester – II	L	T	P	C
CSDS114: DATA MINING AND DATA WAREHOUSING (CORE ELECTIVE-3 OR 4)	3	0	2	4

Course Objective	
1	To introduce students to the basic concepts and techniques of Data Mining.
2	To introduce a wide range of association, clustering, estimation, prediction, and classification algorithms.
3	To introduce mathematical statistics foundations of the Data Mining Algorithms.
4	To introduce basic principles, concepts and applications of Data Warehousing.
5	To build a data mining application from a data warehouse to solve real problems.

OVERVIEW	**(05 Hours)**
Introduction, Data Mining Issues, Data Mining Metrics, Data Mining from a Database Perspective, Data Mining Techniques: Classification, Statistical-Based Algorithms, Decision Tree -Based Algorithms, Neural Network-Based Algorithms, Rule-Based Algorithms, Combining Techniques; Similarity and Distance Measures, Hierarchical Algorithms, Partitioned Algorithms, Clustering Large Databases, Clustering with Categorical Attributes; Basic Algorithms, Advanced Association Rule Techniques, Measuring the Quality of Rules	
MINING STREAM, TIME SERIES AND SEQUENCE DATA	**(10 Hours)**
Mining Data Streams, Methodologies for Stream Data Processing and Stream Data Systems, Frequent-Pattern Mining in Data Streams, Classification of Dynamic Data Streams, Clustering Evolving Data Streams; Trend Analysis, Similarity Search in Time Series Analysis, Sequential Pattern Mining in Transactional Databases, Constraint-Based Mining of Sequential Patterns, Periodicity Analysis for Time-Related Sequence Data; Mining Sequence Patterns, Alignment of Sequences, Hidden Markov Model for Sequence Analysis.	
MULTIMEDIA DATA MINING	**(08 Hours)**
Multimedia Data, Similarity Search in Multimedia Data, Multidimensional Analysis of Multimedia Data, Classification and Prediction Analysis of Multimedia Data, Mining Associations in Multimedia Data, Audio and Video Data Mining.	
SPATIAL DATA MINING	**(08 Hours)**
Spatial Data, Mining Spatial Association and Co-location Patterns, Spatial Classification and Spatial Trend Analysis, Spatial Clustering Methods, Mining Raster Databases	
DATA WAREHOUSING	**(08 Hours)**
Review of Data Warehouse, Multidimensional Data Model, Data Cubes, Process Architecture, OLAP Operations, Stream OLAP and Stream Data Cubes, Generalization of Structured Data, Aggregation and Approximation in Spatial and Multimedia Data Generalization, Generalization of Class Composition Hierarchies, Construction and Mining of Object Cubes, Generalization-Based Mining of Plan Databases by Divide-and-Conquer, Spatial Data Cube Construction and Spatial OLAP.	
APPLICATIONS AND OTHER DM TECHNIQUES	**(06 Hours)**
Mining Event Sequences, Visual DM, Data Stream Mining, Multimedia Mining, Spatial Mining.	
Practical assignment will be based on the coverage of the above topics.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

List of Practical (Problem statements will be changed every year and will be notified on website.)

1	Implementation of an application of a KDD process.
2	Analysis of Data Mining Techniques with Implementations using Java, Python etc.
3	Implementation of Nearest Neighbor Learning and Decision Trees.
4	Analysis of Splitting and Merging Clusters.
5	Implementation of association rule mining algorithms.
6	Mini Project: Implementation of Selected Journal Papers.

BOOKS RECOMMENDED

1. Jiawei Han, Micheline Kamber, "Data Mining: Concepts and Techniques", Morgan Kaufman.
2. Ville, "Decision Trees for Business Intelligence and Data Mining: Using SAS Enterprise Miner", SAS.
3. Pang-Ning Tan, Michael Steinbach, Vipin Kumar, "Introduction to Data Mining", Addison Wesley.
4. Tom Soukup, Ian Davidson, "Visual Data Mining: Techniques and Tools for Data Visualization and Mining", Wiley.
5. Alex Berson, Stephen J. Smith, "Data Warehousing, Data Mining, and OLAP", MGH.

Course Outcomes **At the end of the course, students will**	
CO1	be able to identify the key processes of data mining, data warehousing and knowledge discovery process and understand the basic principles and algorithms used in practical data mining.
CO2	be able to apply data mining techniques to solve problems in other disciplines in a mathematical way.
CO3	be able to analyze the algorithms used in practical data mining and their strengths and weaknesses.
CO4	be able to evaluate different strategies of data warehousing techniques and data mining algorithms.
CO5	be able to design data mining algorithms for real time applications.

M. Tech. – I (CSE) DS Semester – II	L	T	P	C
CSDS116: NATURAL LANGUAGE PROCESSING (CORE ELECTIVE-3 OR 4)	**3**	**0**	**2**	**4**

Course Objective	
1	To comprehend natural language processing in order to extract information.
2	To understand information about language-specific tasks and learning models.
3	To investigate the use of artificial intelligence to comprehend the semantics of text data.
4	To know about text processing at syntactic, semantic, and pragmatic levels.
5	To understand data extraction from unstructured text by identifying references to named entities as well as stated relationships between such entities.

INTRODUCTION AND LANGUAGE MODELING	**(12 Hours)**
Introduction to Computational Linguistics, Word Meaning, Distributional Semantics, Word Sense Disambiguation, Sequence Models, N-gram Language Models, Feed forward Neural Language Models, Word Embedding, Recurrent Neural Language Models, Tokenization, Lemmatization, Stemming, Sentence Segmentation, POS Tagging and Sequence Labeling, Structured Perceptron, Viterbi – Loss, Augmented Structured Prediction, Neural Text Models and Tasks.	
INFORMATION EXTRACTION	**(11 Hours)**
Information Extraction from Text, Sequential Labeling, Named Entity Recognition, Semantic Lexicon Induction, Relation Extraction, Paraphrases Inference Rules, Summarization, Event Extraction, Opinion Extraction, Temporal Information Extraction, Open Information Extraction, Knowledge based Population, Narrative Event Chains and Script Learning, Knowledge Graph Augmented Neural Networks for Natural Language.	
MACHINE TRANSLATION AND ENCODER-DECODER MODELS	**(11 Hours)**
Machine Translation, Encoder-Decoder Models, Beam Search, Attention Models, Multilingual Models, Syntax, Trees, Parsing, Transition based Dependency Parsing, Graph based Dependency Parsing, Transfer Learning, Deep Generative Models for Natural Language Data, Text Analytics, Text Mining, Information Extraction with AQL-Conversational AI.	
APPLICATION AND CASE STUDIES	**(11 Hours)**
Application: Spelling Correction, Sentiment Analysis, Word Sense Disambiguation, Text Classification, Machine Translation, Question Answering System, Intent Detection, False Fact Detection.	
Practical assignments will be based on the coverage of above topics.	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

List of Practical (Problem statements will be changed every year and will be notified on website.)	
1	Create an application in Python with the NLTK library to tokenize the words present in a paragraph.
2	Perform tasks with NLTK (Natural Language Toolkit).
3	Tasks to be Performed in SpacCy Library.
4	Practical based on huggingface library.
5	Text Classification using movie reviews database, etc.
6	Practical implementation of application and case study.

BOOKS RECOMMENDED
1. Emily Bender, "Linguistics Fundamentals for NLP", Morgan Claypool Publishers. 2. Jacob Eisenstein, "Natural Language Processing", The MIT Press. 3. Dan Jurafsky, James H. Martin, "Speech and Language Processing", Prentice Hall. 4. Chris Manning, Hinrich Schutze, "Foundations of Statistical Natural Language Processing", The MIT Press. 5. Pushpak Bhattacharyya, "Machine Translation", CRC Press.

Course Outcomes **At the end of the course, students will**	
CO1	be able to understand how language works, including the word structure, sentence structure, and meaning.
CO2	be able to learn how to reframe NLP problems as learning and inference tasks, as well as how to deal with the associated computational challenges
CO3	be able to use text processing at the syntactic, semantic, and pragmatic levels.
CO4	be able to learn about text mining and manipulation techniques.
CO5	be able to retrieve information from the text and can use it for decision making.

M. Tech. – I (CSE) DS Semester – II	L	T	P	C
CSDS118: DATA SCIENCE FOR SOFTWARE ENGINEERING (CORE ELECTIVE-3 OR 4)	**3**	**0**	2	**4**

Course Objective	
1	To understand various tools of Software Engineering.
2	To understand the capability of software engineering principles to analyze data science applications to make appropriate decisions.
3	To learn various methods and principles of software engineering for data science applications.
4	To learn integration of software engineering principles with data science applications.
5	To learn how to use software engineering for data science.

FORMAL SOFTWARE ENGINEERING	**(06 Hours)**
Formal specifications, Techniques, Verification and Validation, Theorem Provers, Model checking, modeling concurrent systems, Temporal logics, CTL & LTL and model checking, SAT Solvers, Testing Techniques, Test Case Generation	
SOFTWARE REQUIREMENTS AND ESTIMATION	**(04 Hours)**
Software Requirements: What and Why, Software Requirements Engineering, Software Requirements Management, Software Requirements Modeling, Software Estimation, Size Estimation, Effort, Schedule and Cost Estimation, Tools for Requirements Management and Estimation.	
SOFTWARE DEVELOPMENT METHODOLOGIES	**(05 Hours)**
Introduction to Software Engineering, A Generic View of Process, Process Models, Software Requirements, Design Engineering, Creating an Architectural Design, Modeling Component.	
SOFTWARE PROCESS AND PROJECT MANAGEMENT	**(05 Hours)**
Software Process Maturity, Process Reference Models, Software Project Management Renaissance, Life-Cycle Phases and Process artifacts, Workflows and Checkpoints of Process, Process Planning, Project Organizations, Project Control and Process Instrumentation, CCPDS-R Case Study and Future Software Project Management Practices.	
FUNDAMENTALS OF OBJECT ORIENTED DESIGN IN UML	**(05 Hours)**
Static and Dynamic Models, Necessity of Modeling, UML Diagrams, Class Diagrams, Interaction Diagrams, Collaboration Diagram, Sequence Diagram, State Chart Diagram, Activity Diagram, Implementation Diagram.	
USER INTERFACE	**(04 Hours)**
Module Introduction, Objectives of Usability, How to Approach Usability, Designing with Usability in mind, Measuring Usability, Guidelines for User Interface Design, User Interface Elements.	
SOFTWARE QUALITY ASSURANCE AND TESTING	**(04 Hours)**
Software Quality Assurance and Standards, Quality Standards, Software Testing Strategy and Environment, Building Software Testing Process, Software Testing Techniques, Software Testing Tools, Testing Process-Seven Step Testing Process, Specialized Testing Responsibilities.	
DATA SCIENCE PERSPECTIVE FOR SOFTWARE ENGINEERING	**(12 Hours)**
Diverse Sets of Data, Category of Data, Combining Quantitative and Qualitative Methods, Structuring and Summarizing Unstructured Software Data, Validate and Calibrate Data, Generation of Requirement Specifications, Automatic Code Documentation; Software Project Cost Estimation, Software Quality Prediction, Semi-Automatic Refactoring, Prioritization, Automatic Bug Assignment and Test Cases Generation; Case Study-Search Engine: Working of Search Engine, Content Quality Strategy, Control Crawling, Indexing and Ranking, Search Appearance, Optimization.	

Practical assignments will be based on the coverage of above topics.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

List of Practical (Problem statements will be changed every year and will be notified on website.)	
1	Working with software engineering software SPIN.
2	Working with a variety of modules for software engineering.
3	Working with testing of the software project.
4	To develop the software engineering prototype of the application.
5	To analyze the software using a model checker.

BOOKS RECOMMENDED

1. Roger S. Pressman, “Software Engineering: A Practitioner's Approach”, McGraw Hill Higher Education.
2. Ian Sommerville, “Software Engineering”, Pearson Education.
3. Carlo Ghezzi, Mehdi Jazayeri, Dino Mandrioli, “Fundamentals of Software Engineering”, Pearson.
4. Hans van Vliet, “Software Engineering: Principles and Practice”, Wiley.
5. Tim Menzies, Laurie Williams, Thomas Zimmermann, “Perspectives on Data Science for Software Engineering”.

Course Outcomes **At the end of the course, students will**	
CO1	have knowledge about software engineering tools for integrated development environments, syntax checking, testing, debugging, and version control.
CO2	be able to apply software engineering principles to solve Data Science applications.
CO3	be able to critically analyze the Data Science problems to apply software engineering solutions.
CO4	be able to evaluate various Data Science applications using software engineering principles.
CO5	be able to design software engineering principles based applications using Data Science principles.

M. Tech. – I (CSE) DS Semester – II	L	T	P	C
CSDS120: BIG DATA ANALYTICS AND LARGE SCALE COMPUTING (CORE ELECTIVE-3 OR 4)	**3**	**0**	**2**	**4**

Course Objective	
1	To learn the basics of big data, its characteristics, big data management issues, processing and applications with the help of big data platforms and storage models for big data management.
2	To learn the management and analysis of big data using technology like Hadoop, NoSql, MapReduce, PIG & HIVE.
3	To apply the data mining algorithms on big data for scalability of the real time applications.
4	To develop research interest towards advances in data mining by analyzing the available approaches with the help of evaluating parameters.
5	To build big data analytics and management systems with visualization using the latest technology to solve real problems.

INTRODUCTION	**(05 Hours)**
Definition of Big Data, Source of Big Data, Convergence of Key Trends, Unstructured Data, Industry Examples of Big Data, Web Analytics, Fraud and Risk Associated with Big Data, Credit Risk Management, Big Data in Algorithmic Trading, Healthcare, Medicine, Marketing and Advertising, Big Data Technologies, Introduction to Hadoop and Spark, Open Source Technologies, Cloud, Mobile Business Intelligence, Crowd Sourcing Analytics, Inter and Trans Firewall Analytics.	
BIG DATA ANALYTICS	**(06 Hours)**
Big Data Processing: Batch Data Processing and Stream Data Processing, Computing Environments for Big Data Analytics, Implementation of Batch and Real Time Event Processing: Integration of Disparate Data Stores/Data Lake, Mapping Data to the Programming Framework, Connecting and Extracting Data from Storage, Transforming Data for Processing, Querying.	
DISTRIBUTED FILE SYSTEM HADOOP	**(08 Hours)**
Introduction, HDFS Daemons, Different Methods to HDFS Access, Hadoop, Features, Google File System Features, Phases involved in Map Reduce, Architecture, Execution of MapReduce Jobs, Monitoring the progress of job flows, Building Blocks of Hadoop MapReduce. Data format, Analyzing data with Hadoop, Scaling Out, Hadoop Streaming, Hadoop Pipes, Design of Hadoop Distributed File System, MapReduce, HDFS Concepts: Java Interface, Data Flow, Hadoop I/O, Data integrity, Compression, Serialization, Avro, File-based Data Structures, Mahout, Pig, Hive, HBase.	

DISTRIBUTED MACHINE LEARNING	**(08 Hours)**
Review of Machine Learning: Supervised and Unsupervised Learning, Linear algebra; Classification Formulation, Closed Form Solution, Computational Complexity, Grid Search, Computation Storage Communication, Probabilistic Prediction, Backpropagation Graph and Compute Gradients for Model Training, Automatic Differentiation Graph-Level Optimization Parallelization/Distributed Training Data Layout and Distributed Linear Regression and Distributed Logistic Regression, Placement Kernel Optimizations, Memory Optimizations, Distributed Principal Component Analysis, Regularization and Optimization for Training Deep Neural Networks, Sequence Modeling, Federated Learning.	
BIG DATA ANALYSIS WITH MLLIB, SPARKSQL AND GRAPHX	**(06 Hours)**
HBase, Data Model and Implementations, HBase Clients, HBase Examples, Praxis, Cassandra, Cassandra data Model, Cassandra Examples, Cassandra Clients, Hadoop Integration, Hive, Data Types and File Formats,	

HiveQL Data Definition, HiveQL Data Manipulation, HiveQL Queries, Applications on Big Data Using Pig and Hive, Data Processing Operators in Pig, Fundamentals of ZooKeeper, K-Means Clustering, Decision Trees, Random Forests, Recommenders, Table in Spark, Higher Level Declarative Programming, Network Structure, Computing Graph Statistics.	
BIG DATA STORAGE MODELS	**(06 Hours)**
Introduction, NoSQL Databases, Need, Types, Comparison with RDBMS, Architecture and Features of NoSQL Databases: Distributed Hash-table, Key-Value Storage Model, Document Storage Model, Graph Storage Models, Lambda Architecture, Data Ingestion, Design and Provision Compute Resources, Storage Technology, Streaming Units, Configuration of Clusters for Latency and Throughput, Output Visualization.	
SCALABLE ALGORITHMS	**(06 Hours)**
Mining Big Data, Centrality, Similarity, Al-Distances Sketches, Community Detection, Link Analysis, Spectral Techniques, MapReduce, Pig Latin, and NoSQL, Algorithms for Detecting Similar Items, Recommendation Systems, Data Stream Analysis Algorithms, Detecting Frequent Items, Data Ingestion, Storage of Data, Data Transfer, Compute Clusters and Configuration of Design.	
Practical assignments will be based on the coverage of above topics.	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

List of Practical (Problem statements will be changed every year and will be notified on website.)	
1	Working with various functions of Hadoop MapReduce.
2	Working with pySpark and RDDs.
3	Regression and classification in Spark.
4	Data analysis with PCA in Spark.
5	Hands-on with MLlib and SparkSQL.
6	Use cases and implementation for Big data management and large scale machine learning algorithms.

BOOKS RECOMMENDED

1. Ron Bekkerman, Mikhail Bilenko, John Langford, “Scaling up Machine Learning: Parallel and Distributed Approaches”, Cambridge University Press.
2. Michael Minelli, Michele Chambers, Ambiga Dhiraj, “Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley.
3. Michael Berthold, David J. Hand, “Intelligent Data Analysis”, Springer.
4. Tom White, “Hadoop: The Definitive Guide”, O’reilly Media.
5. Arshdeep Bahga, Vijay Madisetti, “Big Data Science & Analytics: A Hands on Approach “, VPT.

ADDITIONAL BOOKS RECOMMENDED

1. Edward Capriolo, Dean Wampler, and Jason Rutherglen, “Programming Hive”, O'Reilly.
2. Lars George, “HBase: The Definitive Guide”, O'Reilly.
3. Eben Hewitt, “Cassandra: The Definitive Guide”, O'Reilly.
4. Alan Gates, “Programming Pig”, O'Reilly.
5. Sandy Ryza, Uri Laserson, Sean Owen, Josh Wills, “Advanced Analytics with Spark”, O'Reilly.
6. Holden Karau, Andy Konwinski, Patrick Wendell, and Matei Zaharia, Learning Spark, O'Reilly.
7. Jure Leskovec, Stanford Univ. Anand Rajaraman, Milliway Labs, Jeffrey D. Ullman, “Mining of Massive Datasets”, Cambridge University Press.
8. Ron Bekkerman, Mikhail Bilenko and John Langford, “Scaling up Machine Learning: Parallel and Distributed Approaches”, Cambridge University Press.
9. Arvind Sathi, “Big Data Analytics: Disruptive Technologies for Changing the Game”, MC Press.
10. Tom Plunkett, Brian Macdonald et al, “Oracle Big Data Handbook”, Oracle Press.

11. Jay Liebowitz, “Big Data and Business analytics”, CRC press.

Course Outcomes **At the end of the course, students will**	
CO1	have knowledge of the key issues in big data management and its associated applications in intelligent business and scientific computing.
CO2	be able to apply theoretical foundations of mining algorithms for the usage applicability of business, engineering and scientific problems for big data processing and scalability.
CO3	be able to analyze Hadoop related tools such as HBase, Cassandra, and Hive for big data analytics.
CO4	be able to evaluate the big data analytics applications and evaluation measures to have a productive solution.
CO5	be able to build a complete business data analytics solution for any real time problem.

M. Tech. – I (CSE) DS Semester – II	L	T	P	C
CSDS122: CYBER PHYSICAL SYSTEMS (CORE ELECTIVE-3 OR 4)	**3**	**0**	**2**	**4**

Course Objective:	
1	To have an understanding of the cyber physical systems and the corresponding important research challenges in this area.
2	To be able to learn the evolution in computing from mainframe computing to the ubiquitous and pervasive computing and the dominant role of the embedded systems.
3	To be able to understand various modelling formalisms for the CPSs, viz. Timed and Hybrid Automata and do the formal analysis using flow pipe construction, reachability analysis of CPS Software.
4	To be able to analyze and design the protocols used in resource constrained environments.
5	To be able to improve the critical reading, presentation, and research skills.

INTRODUCTION	**(04 Hours)**
Introduction to Cyber-Physical Systems. The Industrial Revolution 4.0. Motivation for the IR 4.0. Cyber-Physical Systems (CPS) in the real world.	
WIRELESS SENSOR NETWORK AND INTERNET OF THINGS	**(10 Hours)**
Basic principles of design and validation of CPS. Basic characteristics of the CPSs. The Internet of Things. The Industrial Internet of Things. The Wireless Sensor Networks and the RFID devices as the actors of the CPSs. The Ubiquitous and the Pervasive Computing paradigm introduced by the CPSs. The Applications of the Wireless Sensor Networks. The role of the Internet of Things in realizing Smart Applications. The Characteristics and the issues of deployment.	
CPS HARDWARE	**(09 Hours)**
CPS Hardware Platforms: Processors. Types of Processor. The Processors Design issues. Parallelism. Embedded Processors. Harvard Architecture: Pros and Cons. The Sensors and Actuators. Models of Sensors and Actuators. Common Sensors. Actuators. Memory Architectures. Memory Technologies. Memory Hierarchy. Memory Models. Types of memory in the CPSs. Input and Output Hardware. The design issues. The Analog to Digital convertor.	
CPS OPERATING SYSTEMS AND NETWORKING	**(09 Hours)**
Realtime Operating Systems for the WSN devices. Characteristics. Issues. Thread Scheduling. Basics of Scheduling. Rate Monotonic Scheduling. The Earliest Deadline First Scheduling. Scheduling and Mutual Exclusion. Multiprocessor Scheduling. Sequential Software in a Concurrent World. Multitasking. Imperative Programs. Case studies of the typical OSs. TinyOS, nesC and Contiki. The Simulators for the WSN devices. The CPS Network - WirelessHart, CAN, Automotive Ethernet.	
CPS MODELLING AND ANALYSIS	**(09 Hours)**
Formal Methods for Safety Assurance of Cyber-Physical Systems: Advanced Automata based modelling and analysis, Basic introduction and examples, Timed and Hybrid Automata, Definition of trajectories, Formal Analysis: Flow pipe construction, reachability analysis. Analysis of CPS Software: Weakest Preconditions, Bounded Model checking, CPS software verification: Frama-C, CBMC	
CPS SECURITY	**(04 Hours)**

Secure Deployment of CPS: Attack models, Secure Task mapping and Partitioning, State estimation for attack detection Automotive Case study: Vehicle ABS hacking Power Distribution Case study: Attacks on SmartGrids.	
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED

1. E. A. Lee and S. A. Seshia, "Introduction to Embedded Systems - A Cyber-Physical Systems Approach", Second Edition, The MIT Press, 2017.
2. Rajeev Alur, "Principles of Cyber-Physical Systems", MIT Press, 2015.
3. ZEADALLY S and NafaâJabeur, "Cyber Physical System Design With Senor Networking Technologies", IET Press, 2016.
4. Taha, W. M., Taha, A. M., Thunberg, J. ,"Cyber-Physical Systems: A Model-Based Approach", Germany: Springer International Publishing, 2020
5. Rajkumar, R., de Niz, D., Klein, M, "Cyber-Physical Systems". United Kingdom: Pearson Education, 2016.

Course Outcomes **At the end of the course, students will be able to**	
CO1	Understand the fundamentals of cyber-physical systems (CPS).
CO2	Apply the concepts of CPS to the different paradigms of computing.
CO3	Analyze the design issues associated with different hardware functional units of the CPSs.
CO4	Evaluate the performance impact of thread scheduling algorithms in the CPSs.
CO5	Design CPS solutions for different application domains.

M. Tech. – I (CSE) DS Semester – II	L	T	P	C
CSDS124: MACHINE LEARNING FOR SECURITY (CORE ELECTIVE-3 OR 4)	**3**	**0**	**2**	**4**

Course Objectives	
1	To DESCRIBE the fundamental concepts of machine learning for devising security mechanisms.
2	To ENUMERATE the techniques for Intrusion Detection and Malware detection and analysis using Machine Learning.
3	To learn the machine learning techniques for network traffic analysis
4	To analyse the machine learning approaches for security for probable abuse by the adversary.
5	To design secure machine learning based schemes for malware detection and intrusion detection.

INTRODUCTION & REVIEW OF THE MACHINE LEARNING BASICS	**(04 Hours)**
Review of the basic concepts in Linear Algebra, Probability and Statistics. Introduction to the ML techniques. Machine Learning problems viz. Classification, Regression, Clustering, Association rule learning, Structured output, Ranking. The Supervised and Unsupervised learning algorithms. Linear Regression, Gradient descent for convex functions, Logistics Regression and Bayesian Classification Support Vector Machines, Decision Tree and Random Forest, Neural Networks, DNNs, Ensemble learning. Principal Components Analysis. Un-supervised learning algorithms: K-means for clustering problems, K-NN (k nearest neighbors). Apriori algorithm for association rule learning problems. Generative vs Discriminative learning. Empirical Risk Minimization, loss functions, VC dimension. Data partitioning (Train/test/Validation), cross-validation, Biases and Variances, Regularization.	
MACHINE LEARNING FOR SECURITY	**(05 Hours)**
Introduction to Information Assurance. Review of Cybersecurity Solutions: Proactive Security Solutions, Reactive Security Solutions: Misuse/Signature Detection, Anomaly Detection, Hybrid Detection, Scan Detection. Profiling Modules. Understanding the Fundamental Problems of Machine-Learning Methods in Cybersecurity. Incremental Learning in Cyber infrastructures. Feature Selection/Extraction for Data with Evolving Characteristics. Privacy-Preserving Data Mining. Motivation for ML in security with real-world case studies. Topics of interest in applications of machine learning for security.	
MACHINE LEARNING TECHNQIUES FOR INTRUSION DETECTION	**(08 Hours)**
Emerging Challenges in Cyber Security for Intrusion Detection: Unifying the Current Anomaly Detection Systems, Network Traffic Anomaly Detection. Imbalanced Learning Problem and Advanced Evaluation Metrics for IDS. Reliable Evaluation Data Sets or Data Generation Tools. Privacy Issues in Network Anomaly Detection. Machine Learning Techniques: for Anomaly Detection, for Misuse/Signature detection, for Hybrid detection, for Scan detection. Cost-Sensitive Modeling for Intrusion Detection. Data Cleaning and Enriched Representations for Anomaly Detection in System Calls.	
MACHINE LEARNING TECHNQIUES FOR MALWARE ANALYSIS	**(08 Hours)**
Emerging Cyber Threats in malwares: Threats from Malware, Botnets, Cyber Warfare, Mobile Communication. Cyber Crimes. Malware Analysis: Feature generation, Features to Classification. Taxonomy of malware analysis approaches based on machine learning. Malware Detection, Similarity Analysis, Category Detection. Feature Extraction. PE Features. Supervised, Unsupervised and Semi-supervised learning algorithms for Malware Detection. Using Deep Learning Approaches: Generative Adversarial Networks.	
NETWORK TRAFFIC ANALYSIS & WEB ABUSE DETECTION	**(08 Hours)**
Machine Learning for Profiling Network Traffic: Theory of Network defense (access control, authentication, detecting in-network attackers, data-centric security, honeypots), Predictive model for classifying network	

attacks.	
MACHINE LEARNING IN PRIVACY PRESERVATION	**(06 Hours)**
k-anonymity; l-diversity; deferentially private data storage/release; verifiable differential privacy; privacy-preserving inference of social networking data; privacy-preserving recommender system; privacy versus utility. Machine learning techniques for Privacy Preserving Data Mining.	
ADVERSARIAL MACHINE LEARNING	**(06 Hours)**
Adversarial Machine Learning: Motivation and Background. Practical Scenarios and Examples. Modelling the Adversary: Attack Surface Adversary Goals Adversary capabilities. Taxonomy of Adversarial Attacks on Machine Learning: Influence Specificity Security Violation. Data poisoning; Perturbation; Defense mechanism; Generative Adversarial Networks. A peep into Industry Perspectives: Theme of inference Secure Software Development Life Cycle or Secure Development Cycle. Key Inferences in terms of Security gaps, Suggested panacea.	
Practical assignments will be based on the coverage of above topics.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

BOOKS RECOMMENDED

1. Clarence Chio, David Freeman, Machine Learning and Security. Protecting Systems with Data and Algorithms, O'Reilly Media Publications.
2. Marcus A. Maloof (Ed.), Machine Learning and Data Mining for Computer Security: Methods and Applications, Springer-Verlag London Limited.
3. Sumeet Dua and Xian Du, Data Mining and Machine Learning in Cybersecurity. CRC Press, Taylor and Francis Group, LLC.
4. Research Papers Prescribed in the class.
5. Fei Hu, Xiali Hei, "AI, Machine Learning and Deep Learning: A Security Perspective", United States: CRC Press, 2023.

Course Outcomes
At the end of the course, students will

CO1	have a knowledge of the limitations of the conventional security software in the wake of machine learning based attacks on the security software
CO2	be able to apply the concepts machine learning based intrusion detection to analyze the IDSs.
CO3	be able to analyze the malware analysis and mitigation based solutions for the probable threats therein.
CO4	be able to design the threat models based on machine learning approaches for network analysis.
CO5	be able to use the concepts of machine learning to prevent security design faults.

M. Tech. – I (CSE) DS Semester – II	L	T	P	C
CSDS172: SOCIAL NETWORKS (INSTITUTE ELECTIVE)	**3**	**0**	**0**	**3**

Course Objective	
1	To understand the social network models, representation and analytics.
2	To identify the unique challenges involved in social network research.
3	To apply techniques for social network representation and analytics for real-word scenarios.
4	To analyse and evaluate the social network research solutions for real-world scenarios.

INTRODUCTION	**(09 Hours)**
Introduction To Social Networks: Networks as Information Maps, Networks as Conduits, Connections, Propinquity, Homophily	
SOCIAL NETWORK REPRESENTATION	**(18 Hours)**
Social Network Analysis: Mathematical Foundations, Data Collection, Data Management, Visualization, Centrality, Subgroups, Cliques, Clusters, Dyads and Triads, Density, Structural Holes, Weak Ties, Centrality, The Small World, Circles, and Communities, Multiplicity, Structural Similarity and Structural Equivalence	
SOCIAL NETWORK ANALYSIS	**(09 Hours)**
Social Networks and Diffusion: Influence and Decision-Making, Epidemiology and Network Diffusion, Tipping Points and Thresholds	
TOOLS AND CASE STUDIES	**(09 Hours)**
Social Network Tools and Case Studies	
	(Total Contact Time: 42 Hours)

BOOKS RECOMMENDED

1. Borgatti SP, Everett MG, Johnson JC, “Analyzing Social Networks”, London, Sage Publication.
2. Kadushin C., “Understanding Social Networks: Theories, Concepts and Findings”, Oxford University Press.
3. Piet A.M. Kommers, Pedro Isaias, TomayessIssa, “Perspectives on Social Media: A Yearbook”, Taylor and Francis.
4. Newman Mark, “Networks: An Introduction”, Oxford university press.
5. Brath Richard, David Jonker, "Graph analysis and visualization: Discovering Business Opportunity in Linked Data", John Wiley & Sons.

Course Outcomes At the end of the course, students will	
CO1	have the knowledge of various social network representation, visualization and analytics tools and techniques.
CO2	be able to apply tools for social network data acquisition, management and analytics.
CO3	be able to analyze the social network research solutions for real-world scenarios.
CO4	be able to evaluate the different solutions for performance;
CO5	be able to design the social network analytics solution for the complex real-world problem.

M. Tech. – I (CSE) DS Semester – II	L	T	P	C
CSDS174: CYBER LAWS (INSTITUTE ELECTIVE)	3	0	0	4

Course Objective	
1	The course aims at acquainting the students with the basic concepts of Cyber Law and also puts those concepts in their practical perspective.
2	It also provides an elementary understanding of the authorities under IT Act as well as penalties and offences under IT Act.
3	It also covers overview of Intellectual Property Right and Trademark Related laws with respect to Cyber Space.
4	Student will get the knowledge about the E- Governance policies of India.

INTRODUCTION OF CYBER CRIMES & CYBER LAW	(07 Hours)
Understanding Cyber Crimes and Cyber Offences, Crime in context of Internet, Types of Crime in Internet, Crimes targeting Computers: Definition of Cyber Crime & Computer related Crimes, Constraint and Scope of Cyber Laws, Social Media and its Role in Cyber World, Fake News, Defamation, Online Advertising.	
PREVENTION OF CYBER CRIMES & IT ACT 2000	**(07 Hours)**
Prevention of Cyber Crimes & Frauds, Evolution of the IT Act 2000, Genesis and Necessity. Critical analysis & loop holes of The IT Act, 2000 in terms of cyber-crimes, Cyber Crimes: Freedom of speech in cyber space & human right issues.	
FEATURES OF IT ACT 2000 & AMENDMENTS	**(07 Hours)**
Salient features of the IT Act, 2000, Cyber Tribunal & Appellate Tribunal and other authorities under IT Act and their powers, Penalties & Offences under IT Act, Amendments under IT Act and Impact on other related Acts (Amendments): (a) Amendments to Indian Penal Code. (b) Amendments to Indian Evidence Act. (c) Amendments to Bankers Book Evidence Act. (d) Amendments to Reserve Bank of India Act.	
INDIAN PENAL LAW	**(06 Hours)**
Indian Penal Law and Cyber Crimes: (i) Fraud, (ii) Hacking, (iii) Mischief, Trespass (iv) Defamation (v) Stalking (vi) Spam, Issues of Internet Governance: (i) Freedom of Expression in Internet (ii) Issues of Censorship (iii) Hate Speech (iv) Sedition (v) Libel (vi) Subversion (vii) Privacy, Cyber Appellate Tribunal with Special Reference to the Cyber Regulation Appellate Tribunal (Procedures) Rules 2000.	
GLOBAL IT RULES & IPR	**(06 Hours)**
The Information Technology (Procedures and Safeguards for Interception, Monitoring and Decryption of Information) Rules, 2009 and Corresponding International Legislation in US, UK and Europe, The Information Technology (Procedures and Safeguards for Blocking the access of Information by Public) Rules, 2009 and Corresponding International Legislation in US, UK and Europe, The Information Technology (Reasonable Security Practices and Procedures and Sensitive Personal Data or Information) Rules, 2009 and Corresponding International Legislation in US, UK and Europe, Intellectual Property Right (IPR).	
CYBER SPACE & E-GOVERNANCE IN INDIA	**(06 Hours)**
Cyber and Cyber Space with reference to Democracy and Sovereignty, Developments in Cyber law Jurisprudence, Role of law in Cyber World: Regulation of Cyber Space in India, Role of RBI and Legal Issues in case of e-commerce, E-Governance in India: Law, Policy, Practice.	
CYBER SPACE JURISDICTION	**(06 Hours)**
Cyber Space Jurisdiction (a) Jurisdiction issues under IT Act, 2000. (b) Traditional principals of Jurisdiction	

(c) Extra-terrestrial Jurisdiction (d) Case Laws on Cyber Space Jurisdiction (e) Taxation issues in Cyberspace.	
Practical assignments will be based on the coverage of above topics. (Problem statements will be based on the content discussed in class.)	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

BOOKS RECOMMENDED

1. Vakul Sharma , "Information Technology Law and Practice- Cyber Laws and Laws Relating to E-Commerce", Universal Law Publishing - An imprint of LexisNexis.
2. Duggal Pavan , "Legal Framework on Electronic Commerce and Intellectual Property Rights in Cyberspace", Universal Law Publishing - An imprint of LexisNexis.
3. Yatindra Singh , "Cyber Laws: A Guide to Cyber Laws, Information Technology, Computer Software, Intellectual Property Rights, E-commerce, Taxation, Privacy, Etc. Along with Policies, Guidelines and Agreements", Universal Law Publishing
4. Santosh Kumar, "Cyber Laws & Cyber Crimes", WHITESMANN.
5. Akash Kamal Mishra , "Cyber Laws in India - Fathoming Your Lawful Perplex " , Notion Press, 2020.

Course Outcomes At the end of the course, students will	
CO1	Student will be able to understand the types of Crime in Internet, Crimes targeting Computers and Scope of Cyber Laws.
CO2	Student will be able to apply the cyber laws to related the various evidences of cybercrimes.
CO3	Student will be able to analyze the various evidences of cybercrimes to allied with the particular cyber law.
CO4	Student will be able to evaluate the particular intellectual property rights according to the cyber law.
CO5	Student will be able to design an application to counter the cybercrimes.

M. Tech. – I (CSE) DS Semester – II	L	T	P	C
CSDS176: BUSINESS DATA ANALYTICS (INSTITUTE ELECTIVE)	**3**	**0**	**2**	**4**

Course Objective	
1	Gaining fundamental Knowledge of Business Analytics and Data Science.
2	To become acquainted with the procedures needed to develop, report, and analyze professional data.
3	To deepen analytical skills and investigate data to establish new relationships and patterns.
4	To optimize business decisions and create competitive advantage with Data analytics.
5	To recognize the importance of Visualization tools for Data Analytics in Business.

INTRODUCTION	**(07 Hours)**
Introduction to Business Analytics, Applications, Components, Types of Business Analytics, Transaction Processing versus Analytic Processing, Big Data and Its Components.	
DATA WAREHOUSE	**(12 Hours)**
Sources of Data, Organization of Data, Types of Data (Raw and Processed), Introduction to Data Warehouse, Multidimensional Data Model, Data Marts, Data Integration, ELT, Concepts of OLAP and Data Cube, OLAP Operations, Dimensional Data Modeling - Star, Snowflake Schemas, Hierarchies, Aggregations.	
VISUALIZING DATA	**(08 Hours)**
Structure of Visualization, Organization of Data, Importance of Data Quality, Dealing with Missing and Incomplete Data, Data Classification, Different Kinds of Plots, Charts and Their Usage, Dashboard and Interactive Plots, Visual Data Analysis Techniques, Interaction Techniques, Creating Animated Visualizations.	
DATA MINING FOR BUSINESS	**(10 Hours)**
Data Mining Process, Data Mining Algorithms (Supervised and Unsupervised), Definition and Concept of Data Mining, Benefits of Data Mining, Data Mining Tasks, Text Mining, Web Mining, Spatial Mining, Process Mining, Social Media Analytics, Social Media Metrics.	
APPLICATIONS OF DATA ANALYTICS IN BUSINESS	**(08 Hours)**
Application of Business Analysis using Tableau, BI Tools: IT analytics, Retail Analytics, Process Analytics, Financial Analytics, Healthcare Analytics, Supply Chain Analytics.	
Practical assignments will be based on the coverage of above topics.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

List of Practical (Problem statements will be changed every year and will be notified on website.)	
1	Working with R studio software to use various data types and objects.
2	Working with Tableau, Data transformation with Visual concepts.
3	Working Power BI with Power Apps and Power Automate to build business applications and automate workflows.
4	Working with Python Programming to solve data manipulation, analysis for business, etc.
5	Problems based on Data Mining techniques.

BOOKS RECOMMENDED

1. Ramesh Sharda, Dursun Delen, Efraim Turban, and David King, “Business Intelligence, Analytics, and Data Science: A Managerial Perspective”, Pearson Education Limited.
2. Noah Iliinsky and Julie Steele, “Designing Data Visualizations”, O’Reilly.
3. Foster Provost and Tom Fawcett, “Data Science for Business: What You Need to Know”, O’Reilly.
4. Melissa Barker, Donald I. Barker, Nicholas F. Bormann, Debra Zahay, “Social Media Marketing: A Strategic Approach”, Cengage Learning.
5. Ger Koole, “An Introduction to Business Analytics”, MG Books.

ADDITIONAL BOOKS RECOMMENDED

1. Laura Igual, Santi Seguí, “Introduction to Data Science”, Springer.
2. Michael Minelli, Michele Chambers, Ambiga Dhiraj, “Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley.
3. Arshdeep Bahga, Vijay Madisetti, “Big Data Science & Analytics: A Hands on Approach “, VPT.

Course Outcomes

At the end of the course, students will

CO1	have knowledge about various data tools and techniques needed in business decision making.
CO2	be able to apply different tools and functions of various software’s to visualize a variety of data in the appropriate form of visualization.
CO3	be able to critically analyze the business problems and apply analytical knowledge in big data.
CO4	be able to evaluate various data analytical techniques.
CO5	be able to design business analytical applications using Data Science principles for the decision making process.

M. Tech.

Computer Science and Engineering

(CSE)

with specialization in

Information Security and Privacy

Department of Computer Science and Engineering

M.Tech. Computer Science and Engineering with specialization in Information Security and Privacy

Sr. No.	Subject	Code	Scheme L-T-P	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
				Th. Marks	T Marks	P Marks		
	First Semester							
1	Mathematical Foundations of Information Security (Core – 1)	CSIS101	3-1-0	100	25	0	4	70
2	Design and Analysis of Algorithms (Core – 2)	CSIS103	3-0-2	100	0	50	4	85
3	Principles of Information Security and Privacy (Core – 3)	CSIS105	3-0-2	100	0	50	4	85
4	Core Elective -1	CSIS1XX	3-1-0 / 3-0-2	100	0 / 25	0 / 50	4	70 / 85
5	Core Elective - 2	CSIS1XX	3-0-2	100	0	50	4	85
						Total	**20**	**395 - 410**
6	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	CSISV91 CSISP93	0-0-10				5	200 (20 x 10)
	Second Semester							
1	Information Theory and Coding (Core – 4)	CSIS102	3-1-0	100	25	0	4	70
2	Network Security (Core – 5)	CSIS104	3-0-2	100	0	50	4	85
3	Elective - 3	CSIS1XX	3-1-0 / 3-0-2	100	0 / 25	0 / 50	4	70 / 85
4	Elective - 4	CSIS1XX	3-0-2	100	0	50	4	85
5	Institute Elective*	CSIS1XX	3-0-0 / 3-0-2 / 3-1-0	100	0 / 25	0 / 50	3 / 4	55 / 70 / 85
6	Mini Project	CSIS1XX	0-0-4	-	-	100	2	70
						Total	**21 – 22**	**435 - 480**
7	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	CSISV92 CSISP94	0-0-10				5	200 (20 x 10)
	Third Semester							
1	MOOC course – I*	Φ	-	-	-	-	3 / 4	70 / 80
2	MOOC course – II*	Φ	-	-	-	-	3 / 4	70 / 80
3	Dissertation Preliminaries	CSIS295	-	-	-	350$	14	560
						Total	**20 - 22**	**700 - 720**
	Fourth Semester							
1	Dissertation	CSIS296	-	-	-	600$	20	800
						Total	**20**	**800**

L: Lecture; T: Tutorial; P: Practical; Th: Theory

*****to be offered to the PG students of other department and other PG Programs with the department.

Subject Code: Core, Electives, Dissertation Preliminary and Dissertation: **$$##nXX;** Vocational Training: **$$##VXX;** Professional Experience: **$$##PXX; $$:** Department Name; **##**: M.Tech Course Identity; **n**: Year; **XX**: Core (01 to 10), Elective (11 to 70), Institute Elective (71 to 90), Vocational Training (91 to 92), Professional Experience (93 to 94), Dissertation Preliminary (95), Dissertation (96), XX last digit odd number (for odd semester); XX last digit even number (for even semester)

Calculation of Notional Hours for the subject containing Theory, Tutorial and Practical Example: 3-1-2: 3*15+1*15+2*15+10 (Exam)= 100

$ **Internal**: 40% and **External**: 60%, *Swayam/NPTEL, ϕ As per 66th IAAC, Dated 20th March, 2024, Resolution No. 66.34 and 61st Senate resolution No. 4, 25th April, 2024.

Code	Elective Subjects	Scheme
	Core Elective 1 and 2	
CSIS111	Modern Cryptography	3-1-0
CSIS113	Cloud Computing and Big Data Analytics	3-0-2
CSIS115	Machine Learning	3-0-2
CSIS117	Cyber Physical Systems	3-0-2
CSIS119	Digital Forensics	3-0-2
CSIS121	Defensible Security Architectures	3-0-2
CSIS123	Research Methodology in CSE	3-1-0
CSIS125	Blockchain Fundamentals and Use Cases	3-0-2
	Core Elective 3 and 4	
CSIS112	Machine Learning for Security	3-0-2
CSIS118	Software Security	3-0-2
CSIS120	Security and Privacy in the Resource Constrained Environments	3-0-2
CSIS122	Security and Privacy in Social Networks	3-0-2
CSIS126	Adversarial Machine Learning	3-0-2
CSIS128	Mobile Security and Penetration Testing	3-0-2
CSIS130	Secure Software Engineering	3-0-2
CSIS132	Foundations of Privacy Engineering	3-1-0
CSIS134	Bitcoin and Cryptocurrency Technologies	3-0-2
CSIS136	Advanced Cryptography	3-0-2
CSIS138	Security Protocols	3-0-2
CSIS140	Hardware Security	3-0-2
	Institute Elective	
CSIS172	Social Networks	3-0-0
CSIS174	Cyber Laws	3-0-0
CSIS176	Ethical Hacking and Penetration Testing	3-0-2

M. Tech. – I (CSE) ISP Semester – I	L	T	P	C
CSIS101: MATHEMATICAL FOUNDATIONS OF COMPUTER SCIENCE (CORE -1)	**3**	**1**	**0**	**4**

Course Objective	
1	To define and analyse the fundamental concepts of set theory and functions.
2	To study group theory, its applications in the area of cryptography.
3	To analyse the properties of polynomial arithmetic and perform different arithmetic operations.
4	To enable the student to apply the knowledge of abstract algebra in modern cryptosystems.
5	To write rigorous proofs of mathematical results and enhances problem solving skill.

PRELIMINARIES	**(07 Hours)**
Sets, functions, equivalence relations and partitions, mathematical induction.	
GROUPS	**(09 Hours)**
Elementary properties, subgroups, cosets, Lagrange's theorem, Euler's theorem, Fermat's theorem, normal groups, quotient groups, cyclic groups, finite cyclic groups and their properties, homomorphism and isomorphism, Isomorphism theorem, permutation groups, Sylow's theorem and application.	
RINGS AND FIELDS	**(09 Hours)**
Rings, units and zero divisors. Ideals and quotients, principal ideals, prime ideals, maximal ideals, integral domain, PID, Euclidean domain, UFD, Euclidean algorithm for GCD, extended Euclidean algorithm, finding modular inverse of an integer, Chinese RemainderTheorem (CRT), Euler's Phi-function, quadratic residues, fields and field extensions, algebraic extensions, splitting fields.	
FINITE FIELDS	**(10 Hours)**
Construction and examples finite fields, Prime Fields, Binary Extension Field, Arithmetic Operations in Prime Field, Arithmetic Operations in Binary Extension Field, Characterization of finite fields	
POLYNOMIALS	**(10 Hours)**
Roots of irreducible polynomials, Traces, Norms and Bases, Roots of Unity and Cyclotomic polynomials, Order of polynomials and Primitive Polynomials, Irreducible polynomials, Construction of Irreducible polynomials.	
Tutorial Assignments will be based on the coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)

BOOKS RECOMMENDED

1. J. B. Fraleigh, "First Course in Abstract Algebra", Narosa/Addison-Wesley, New Delhi.
2. I N Herstein, "Topics in Algebra, Vikas Publications", New Delhi.
3. R. Lidl and H. Niederreiter, "Introduction to Finite Fields and their Applications", Cambridge University Press, London.
4. David S. Dummit and Richard M. Foote, "Abstract Algebra", 3rd Edition, Wiley.
5. Singh, Y. N, "Mathematical Foundation of Computer Science. India" New Age International (P) Limited Publishers, 2005.

Course Outcomes **At the end of the course, students will be able to**	
CO1	differentiate among groups, rings and finite fields.

CO2	analyze the algebraic properties of groups, rings and finite fields.
CO3	apply the fundamentals to design and analyze modern day cryptosystems.
CO4	check if a given polynomial is irreducible over a finite field.
CO5	prove essential formal mathematical properties.

M. Tech. – I (CSE) ISP Semester – I	L	T	P	C
CSIS103: DESIGN AND ANALYSIS OF ALGORITHMS (CORE -2)	**3**	**0**	**2**	**4**

Course Objective	
1	To understand paradigms and approaches used to analyse and design algorithms and to appreciate the impact of algorithm design in practice.
2	To analyse the worst-case time complexity of an algorithm, asymptotic complexities of different algorithms.
3	To design and prove the correctness of the algorithms using appropriate design technique to solve a given real-world computational problem.
4	To analyse and prove the computational intractability of the algorithms of the hard computational problems.
5	To design sub-optimal solutions for the intractable computational problems using alternate design approaches.

INTRODUCTION	**(02 Hours)**
Review of Basis concepts in Algorithms, Abstract Machines, Analysis Techniques: Mathematical, Empirical and Asymptotic analysis, Review of the notations in asymptotic analysis, Recurrence Relations and Solving Recurrences, Proof Techniques – Illustrations	
DIVIDE AND CONQUER APPROACH	**(06 Hours)**
Review of Sorting & order statistics. Various Comparison based Sorts. Analysis. Medians and Order Statistics. The Union-Find problem, Counting Inversions - Finding the closest pair of points. Lower Bound on Sorting and Non-comparison based sorts.	
SEARCHING AN DSET MANIPULATION	**(02 Hours)**
Searching in static table binary search, path lengths in binary trees and applications. Optimality of binary search in worst cast and average-case. Binary search trees, construction of optimal weighted binary search trees. Searching in dynamic table, randomly grown binary search trees, AVL and (a, b) trees.	
HASHING	**(02 Hours)**
Basic ingredients, analysis of hashing with chaining and with open addressing. Union-Find problem: Tree representation of a set, weighted union and path compression-analysis and applications.	
GREEDY DESIGN TECHNIQUE	**(06 Hours)**
Review of Basic Greedy Control Abstraction, Activity Selection Problem & variants, Huffman Coding, Horn Formulas. The Knapsack Problem - Clustering; Minimum-Cost Arborescence. Multi-phase Greedy algorithms. Graph Algorithms. Graph problems: Graph searching. BFS, DFS, shortest first search Minimum Spanning Trees - Single Source Shortest Paths - Maximum Bipartite Cover Problem – Applications., topological sort; connected and bi-connected components. Johnson's implementation of Prim's algorithm using priority queue data structures.	
DYNAMIC PROGRAMMING	**(08 Hours)**
The Coin Changing problem – The Longest Common Subsequence - The 0/1 Knapsack problem, Memoization, Dynamic Programming over Intervals - Shortest Paths and Distance Vector Protocols, Constructing Optimal Binary Search Trees, Algebraic problems: Evaluation of polynomials with or without preprocessing, Winograd's and Strassen's matrix multiplication algorithms and applications to related problems, FFT, simple lower bound results.	
STRING PROCESSING	**(02 Hours)**

String searching and Pattern matching, Knuth-Morris-Pratt algorithm and its analysis, Probabilistic Algorithms.	
BACKTRACKING AND BRANCH & BOUND	**(04 Hours)**
Backtracking, General method, 8-queens problem, Sum of subsets problem, Graph coloring, Hamiltonian cycles. Branch and Bound to solve combinatorial optimization problems	
NP Theory	**(08 hours)**
Polynomial time verification - NP-completeness & the Search Problems - The reductions - Dealing with NP-completeness - Local Search Heuristics – Space complexity. Selected topics - Algorithms for String Matching - Amortized Analysis - Bloom Filters & their applications	
PROBABILISTIC ALGORITHMS	**(02 Hours)**
Indicator Random Variables - Four main design categories - Randomization of deterministic algorithms - Monte Carlo Algorithms - Las Vegas Algorithms - Numerical Probabilistic Algorithms & Various candidate applications therein.	
APPROXIMATION ALGORITHMS	**(03 Hours)**
Introduction and Motivation for Approximation Algorithms – Greedy and combinatorial methods. Scheduling: multiprocessor scheduling.	
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

List of Practical	
1	Lab assignments based on designing algorithms for trivial computational problems and doing their empirical timing analysis.
2	Lab assignments based on designing algorithms using divide and conquer technique and doing their empirical timing analysis.
3	Lab assignments based on designing algorithms using greedy technique and doing their empirical timing analysis.
4	Lab assignments based on designing algorithms using dynamic programming and doing their empirical timing analysis.
5	Lab assignments based on backtracking & branch bound approach to design algorithms.
6	Lab assignments based on designing Approximation algorithms to solve the hard computational problems.

BOOKS RECOMMENDED

1. Cormen, Leiserson, Rivest, Stein, “ Introduction to Algorithms”, the MIT Press.
2. Knuth, Donald E.: “The Art of Computer Programming, Vol I &III”, Pearson Education.
3. Sara Baase , Allen van Gelder , “Computer Algorithms” , Pearson Education.
4. Ellis Horowitz, Sartaj Sahni, “Data Structures, Algorithms and Applications in C++”, Universities Press/Orient Longman.
5. J. Kleinberg, E. Tardos: “Algorithm Design”, Pearson Education.

ADDITIONAL BOOKS RECOMMENDED

1. K. Mehlhom, “Data Structures and Algorithms, Vol. 1 and Vol. 2”, Springer-Verlag, Berlin.
2. A. Borodin and I. Munro, “The Computational Complexity of Algebraic and Numeric Problems”, American Elsevier, New York.
3. D. E. Knuth, “The Art of Computer Programming, Vol. 1, Vol. 2 and Vol. 3”, Narosa/AddisonWesley, New Delhi/London.
4. Winograd, “The Arithmetic Complexity of Computation”, SIAM, New York.

Course Outcomes **At the end of the course, students will**	
CO1	have knowledge about the application of mathematical formula/technique to solve the computational problem.
CO2	be able to understand, identify and apply the most appropriate algorithm design technique required to solve a given problem
CO3	be able to analyze and compare the asymptotic time and space complexities of algorithms.
CO4	be able to write rigorous correctness proofs or implementation for algorithms.
CO5	be able to design and give the solution using innovate/synthesize algorithms to solve the computational problems.

M. Tech. – I (CSE) ISP Semester – I	L	T	P	C
CSIS105: Principles of Information Security and Privacy (CORE -3)	**3**	**0**	**2**	**4**

Course Objective	
1	To understand the basic principles of Information Security & Privacy management.
2	To understand the basic concepts of the technical components involved in implementing security & privacy.
3	To understand that ensuring information security & privacy in a modern organization is a problem for the management to solve and not one that the technology alone can address.
4	To analyze the important economic and commercial consequences of devising security and privacy solutions in an enterprise or the lack thereof.

INTRODUCTION	**(04 Hours)**
Introduction to Information Security and Privacy: Review of the essential terminologies, basic concepts of security and privacy. Relation or lack thereof between the Information Security, Network Security, Systems Security and the Cyber Security. Key principles of Information Security in terms of Security mechanisms, security attributes and the security attacks. Role of National Security Systems (CNSS) and CERTIN. The McCumber Cube for Security. Introduction to the Security Systems Development Life Cycle and the difference between the Software Security and the Security Software. Classical Security Models.	
SECURITY THREATS AND SECURITY ATTACKS	**(03 Hours)**
Taxonomy of Security attacks. Illustrations of typical attacks. Cyber security threats. The basic terminologies viz. threats, defects, vulnerabilities, exploits, attacks, bugs.	
INTRODUCTION TO INFORMATION PRIVACY	**(05 Hours)**
The importance of Data privacy; Privacy rules; Data Protection – Organization Roles. Approaches to protect sensitive data. Personally Identifiable Information and Sensitive Data. Data Privacy And Protection Responsibilities. Consequences Of Privacy Unawareness. Overview Of Global Data Privacy Laws. The DSCI Privacy Framework for global privacy best practices and frameworks.	
SECURITY TECHNOLOGY – I	**(06 Hours)**
Security Mechanisms: The Symmetric and Asymmetric Key Cryptography, Ciphers: Cryptographic Algorithms and the Cryptosystems, Mechanisms for Data Integrity and Entity Authentication, Access Control mechanisms.	
SECURITY TECHNOLOGY – II	**(06 Hours)**
Cryptographic Tools: The Public-Key-Infrastructure (PKI), Digital Signatures, Digital Certificates, Hybrid Cryptographic Systems, Steganography. The Public Key Cryptography (PKC) limitations and looking beyond the PKC.	
SECURITY TECHNOLOGY – III	**(06 Hours)**
Protocols for Secure Communications: S-HTTP, TLS for Secure Internet Communication, S/MIME, PEM, PGP for Secure Email, the SET, TLS, and S-HTTP for Securing Web Transactions, WEP and WPA for Secure Wireless Communications, Securing TCP/IP with IPSec PGP.	
SECURITY TECHNOLOGY – IV	**(06 Hours)**
Firewalls: Processing Modes, Categorized by Generations, by Structure, Architectures, Selecting the right firewall, Configuring and Managing Firewalls. Remote Access, the concept of Virtual Private Networks.	
SECURITY TECHNOLOGY – V	**(06 Hours)**

Intrusion Detection and Prevention Systems: Why use IDPSs, Types, IDPSs Detection Methods, IDPS Response Behaviour, IDPS Approaches. Strengths and Limitations. Deployment and Implementation of IDPSs. Measuring the effectiveness of IDPSs. Honeypots, Honeynets and Padded Cell Systems. Network Reconnaissance: Network Scanning and Analysis.	
OTHER TOPICS	**(03 Hours)**
Legal and Ethical Issues in Information Security and Privacy. Introduction to Cyber Laws. Introduction to Security policies and Security Acts.	
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED

1. Michael E. Whitman, Herbert J. Mattord, “Principles of Information Security”, Course Technology Press, 4th edition, 2011.
2. Dieter Gollmann, “Computer Security”, Wiley, 3rd edition, 2014.
3. Gurpreet Dhillon, John Wiley & Sons, “Principles of Information Systems Security: Texts and Cases”, 1st edition, 2006.
4. Andy Taylor, David Alexander, Amanda Finch, David Sutton, “Information Security Management Principles”, 3rd edition, BCS, The Chartered Institute for IT Publishers, 2020.
5. David Sutton, “Cyber Security: A practitioner's guide”, BCS, The Chartered Institute for IT Publishers, 2017.

Course Outcomes **At the end of the course, students will be able to**	
CO1	Examine and apply the fundamental techniques of computer security.
CO2	Examine and apply and identify potential security issues and the associated risks.
CO3	Demonstrate responsible computer use as it deals with social, political, legal and ethical issues in today's electronic society.
CO4	Demonstrate foundation knowledge of information security/assurance within the organization.
CO5	Plan for the future and design a solution based on user requirements. Explain business continuity, backup and disaster recovery. Understand troubleshooting and quality consumer support.

M. Tech. – I (CSE) ISP Semester – II	L	T	P	C
CSIS102: INFORMATION THEORY AND CODING (CORE – 4)	**3**	**1**	**0**	**4**

Course Objective	
1	to introduce the principles and applications of information theory.
2	to study about the channel and its capacity, information measure, entropy and coding methods.
3	to teach robust coding schemes and error detection & correcting codes.
4	to learn the concepts of distortion rate, channel capacity and types of channels.
5	to enable the students to design the communication system using efficient coding techniques.

INTRODUCTION	**(05 Hours)**
Information Source, Symbols, and Entropy, Mutual information, information Measures for Continuous Random Variable, Joint and Conditional Entropy, Relative Entropy, Applications Based on information Theoretic Approach.	
SOURCE CODING	**(08 Hours)**
Source Coding Theorem, Kraft inequality, Shannon-Fano Codes, Huffman Codes, Run Length Code, Arithmetic Codes, Lempel-Ziv-Welch Algorithm, Universal Source Codes, Prefix Codes, Variable Length Codes, Uniquely Decodable Codes, instantaneous Codes, Shannon's Theorem, Shannon Fano Encoding Algorithm, Shannon's Noiseless Coding Theorem, Shannon's Noisy Coding Theorem.	
COMMUNICATION CHANNEL	**(08 Hours)**
Channel and its Capacity, Continuous and Gaussian Channels, Discrete Memory-Less Channels, Symmetric Channel, Binary Erasure Channel, Estimation of Channel Capacity, Noiseless Channel, Channel Efficiency, Shannon's Theorem on Channel Capacity, Mimo Channels, Channel Capacity with Feedback.	
VIDEO AND SPEECH CODING	**(07 Hours)**
Video Coding Basics, Quantization, Symbol Encoding, Intraframe Coding, Predictive Coding, Transform Coding, Subband Coding, Vector Quantization, Interframe Coding, Motion Compensated Coding, Image Compression, Jpeg, LZ78 Compression, Dictionary Based Compression, Statistical Modelling, Speech Coding, Psycho-Acousting Modelling, Time Frequency Mapping Quantization, Variable Length Coding, Multichannel Correlation and Irrelevancy, Long Term Correlation, Pre-Echo Control, Bit Allocation.	
ERROR CONTROL CODING	**(12 Hours)**
Overview of Field, Group, Galois Field, Types of Codes, Hamming Weight, Minimum Distance Based Codes, Error Detection and Error Correction Theorems, Maximum Likelihood Decoder, Map Decoder, Linear Block Codes and Their Properties, Equivalent Codes, Generator Matrix and Parity Check Matrix, Systematic Codes, Cyclic Codes, Convolution Codes and Viterbi Decoding Algorithm, Iterative Decoding, Turbo Codes and Low Density-Parity-Check Codes, Asymptotic Equipartition Property, Bch Codes, Generator Polynomials, Decoding of Bch Codes, Reed Solomon Codes, Trellis Codes, Space Time Coding.	
RATE DISTORTION THEORY	**(05 Hours)**
Rate Distortion Function, Random Source Codes, Joint Source-Channel Coding and the Separation Theorem.	
Tutorial Assignments will be based on the coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(15 Hours)**

(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)

BOOKS RECOMMENDED	
1.	R. Bose, “Information Theory, Coding and Cryptography”, McGraw-Hill, 3rd Ed., 2016.
2.	T. M. Cover and J. A. Thomas,” Elements of information Theory”, John Wiley & Sons, New York, 2012.
3.	A. B. Robert, “Information Theory”, Dover Special Priced Titles, 2007.
4.	R. M. Roth, “Introduction to Coding Theory”, Cambridge University Press, 2006.
5.	Reza, ”An introduction to information Theory”, Dover, 1994.

Course Outcomes At the end of the course, students will	
CO1	have knowledge about the importance of coding techniques in communication systems and different methods for the same.
CO2	be able to apply information theory concepts and linear algebra in source coding and channel coding.
CO3	be able to analyze the performance of different channel coding techniques using different error control techniques.
CO4	be able to evaluate different types of channels using different coding techniques using statistical techniques.
CO5	be able to design and innovate a solution using the knowledge of coding techniques and rate distortion theory for different types of communication channels.

M. Tech. – I (CSE) ISP Semester – II	L	T	P	C
CSIS104: NETWORK SECURITY (CORE - 5)	**3**	**0**	**2**	**4**

Course Objective	
1	To understand basics of network security, computer and network security threats and basic paradigms and approaches used in network security at various layers.
2	To analyze existing authentication and key agreement protocols and to identify weaknesses of these protocols.
3	To acquire knowledge on standard algorithms used to provide confidentiality, integrity and authenticity.
4	To develop basic skills of secure network architecture and addressing network security issues, challenges and mechanisms.
5	To develop various security solutions against real life security threats.

INTRODUCTION	**(08 Hours)**
Model for Network Security, Network Security Threats, Attacks and Countermeasures, Importance of Effective Network Security Strategies, Overview of Cryptographic Primitives	
SECURITY AT THE APPLICATION LAYER	**(08 Hours)**
S/MIME-Functionality, Messages and Certificate Processing, Domain Keys Identified Mail, Pretty Good Privacy (PGP), GNU Privacy Guard (GPG)	
SECURITY AT THE TRANSPORT LAYER	**(07 Hours)**
SSL/TLS Architecture, Handshake Protocol, Change Cipher Spec Protocol, Alert Protocol, Record Protocol, SSL Message formats, Https, Secure Shell (SSH).	
SECURITY AT THE NETWORK LAYER	**(07 Hours)**
IP Security Overview, IP Security Policy, Encapsulating Security Payload, internet Key Exchange, Authentication Header.	
WIRELESS NETWORK SECURITY	**(07 Hours)**
Wireless Security, Mobile Device Security, IEEE 802.11i Wireless LAN Security, WEP and WPA Protocols.	
NETWORK ACCESS CONTROL AND CLOUD SECURITY	**(08 Hours)**
Network Access Control, Extensible Authentication Protocol, IEEE 802.1x Port-Based Network Access Control, Cloud Computing, Cloud Security Risks and Countermeasures, Data Protection in the Cloud, Cloud Security as a Service, Addressing Cloud Computing Security Concerns.	

Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED

1. William Stallings, “Network Security Essentials: Applications and Standards”, Fourth Edition, 2011.
2. Charlie Kaufman, Radia Perlman, Mike Speciner, “Network Security: Private Communication in a Public World”, 2nd Ed., Prentice Hall PT, 2002.
3. William Stallings, “Cryptography and Network Security: Principles and Practice”, 7th Ed. Pearson, 2017.

4. Behrouz forouzan, Debdeep Mukhopadhyay, “Cryptography and Network Security”, 2nd Ed., Tata McGraw-Hill Education. 2010.
5. Chris McNab, “Network Security Assessment”. 3rd Ed., O'Reilly Media, 2004.

Course Outcomes **At the end of the course, students will**	
CO1	be able to assess vulnerability and weaknesses in the network.
CO2	be able to understand network security techniques to protect against threats in the network.
CO3	be able to analyze different network security techniques to identify, classify the network security threats and select suitable for the given application scenario.
CO4	be able to set up firewall and intrusion detection system for organization’s security and evaluate possible threats and attacks at various layers of TCP/IP suite.
CO5	be able to design robust and efficient system for network security for organizations.

M. Tech. – I (CSE) ISP Semester – I	L	T	P	C
CSIS111: MODERN CRYPTOGRAPHY (CORE ELECTIVE-1 OR 2)	**3**	**1**	**0**	**4**

Course Objective	
1	to understand group theory, number theory, and discrete probability.
2	to analyze probabilistic algorithms.
3	to develop the ability to model security problems and to write security proofs.
4	to understand fundamental cryptographic primitives including Key Exchange, Digital Signatures, Oblivious Transfer, Public-Key Encryption, Commitment.
5	to understand basic computational problems that are important for cryptography such factoring problem, the RSA problem, the discrete-logarithm problem.

INTRODUCTION	**(04 Hours)**
Classical Cryptography and Modern Cryptography, Principles of Modern Cryptography, formal Definitions, Precise Assumptions, Proofs of Security, Provable Security and Real-World Security	
PERFECTLY SECRET ENCRYPTION	**(04 Hours)**
Formal Definitions, Shannon’s Theory, one-Time Pad, Limitations of Perfect Secrecy.	
PRIVATE-KEY ENCRYPTION	**(06 Hours)**
Defining Computationally Secure Encryption, Semantic Security, Constructing Secure Encryption Schemes-Pseudorandom Generators and Stream Ciphers, Proofs by Reduction, Cryptanalytic Attacks-Chosen-Plaintext Attacks and CPA-Security, Constructing CPA-Secure Encryption Schemes, Pseudorandom Functions and Block Ciphers, Cpa-Secure Encryption From Pseudorandom Functions, Chosen-Ciphertext Attacks- Defining CCA-Security.	
HASH FUNCTIONS AND APPLICATIONS	**(05 Hours)**
Hash Functions-one-Wayness and Collision Resistance, Merkle–Damgard Construction, Attacks on Hash Functions-Birthday Attacks, Random-oracle Model, Merkle Trees.	
MESSAGE AUTHENTICATION CODES	**(06 Hours)**
Message Authentication Codes – formal Definitions, Design, and Proof of Security, HMAC, CBC-MAC, Authenticated Encryption, information-Theoretic Macs, Limitations on information-Theoretic Macs	
ALGORITHMS FOR FACTORING AND COMPUTING DISCRETE LOGARITHMS	**(06 Hours)**
Algorithms for Factoring-Pollard’s $P - 1$ Algorithm, Pollard’s Rho Algorithm , Quadratic Sieve Algorithm, Algorithms for Computing Discrete Logarithms- Pohlig–Hellman Algorithm, Baby-Step/Giant-Step Algorithm, Discrete Logarithms From Collisions, index Calculus Algorithm.	
PUBLIC-KEY ENCRYPTION	**(06 Hours)**
RSA Encryption, Security Against Chosen-Plaintext Attacks, Security Against Chosen-Ciphertext Attacks, RSA Implementation Issues and Pitfalls, Computational Diffie-Hellman/Decisional Diffie-Hellman Based Encryption, Elliptic Curve Cryptography-Elliptic Curve Over Finite Fields and Binary Fields, Point Addition Operation, Elliptic Curve Discrete Logarithm Problem, Cryptosystems Based on Elliptic Curve.	
ADVANCED TOPICS	**(08 Hours)**
Zero-Knowledge Proofs, Secret Sharing Schemes, Lattices and Cryptography	
Tutorial Assignments will be based on the coverage of above topics.	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)

BOOKS RECOMMENDED
1. Katz & Lindell, "Introduction to Modern Cryptography: Principles and Protocols", Second Edition, Publisher: Chapman & Hall/CRC, 2014. 2. Douglas R. Stinson, " Cryptography: Theory and Practice", Third Edition, Publisher: Chapman and Hall/CRC, 2005. 3. Goldreich, "Foundations of Cryptography", Cambridge University Press, 2005 (Volume 1 and 2). 4. William Stallings, "Cryptography and Network Security: Principles and Practice", 7th Ed. Pearson, 2017. 5. Katz, Jonathan, and Lindell, Yehuda, " Introduction to Modern Cryptography". United States, CRC Press, 2020.

Course Outcomes **At the end of the course, students will**	
CO1	communicate formal security definitions, security assumptions and security proofs of modern cryptosystems.
CO2	differentiate various deterministic and probabilistic algorithms and understand their applicability in real-world application scenarios.
CO3	present the security models and security proofs of well-known algorithms.
CO4	demonstrate familiarity with fundamental cryptographic primitives and apply the knowledge to various application domains.
CO5	compare number theoretic problems used by cryptographic algorithms and evaluate their respective strengths and weaknesses.

M. Tech. – I (CSE) ISP Semester – I	L	T	P	C
CSIS113: CLOUD COMPUTING AND BIG DATA ANALYTICS (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	To understand the cloud computing and Big data platform and its use cases.
2	To identify the techniques achieving cloud based big data analytics with scalability and streaming capability.
3	To apply different algorithms and techniques of big data analytics using appropriate cloud platforms to solve complex problems.
4	To analyse and evaluate suitable cloud paradigms and big data analytics algorithms and techniques to give solutions for complex problems.
5	To design and give solutions for given problems through big data analytics tools and cloud platform.

INTRODUCTION	**(09 Hours)**
History and introduction of Cloud Computing, Big Data Analytics, Data Warehousing, Data Mining	
CLOUD COMPUTING	**(09 Hours)**
Virtualization, SOA, Programming Model, Resource Management and Scheduling, Application building for Managing and Analyzing Data	
BIG DATA ANALYTICS	**(09 Hours)**
Concepts and Techniques in Data Warehousing, Concept Description and Association Rule Mining, Classification and Prediction, Hadoop Map-Reduce Platforms, Stream Computing Platforms and Algorithms	
NOSQL DATABASES AND SCALABLE DATA STORAGE	**(09 Hours)**
Graph databases, Mongo and Cassandra	
ADVANCED TOPICS	**(09 Hours)**
Structured and high dimensional data, Real time stream analytics, Generalized functional decomposition, Apache Spark and Storm	
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED

1. J. Leskovec, A. Rajaraman, J. D. Ullman, “Mining of Massive Datasets”, Cambridge
2. White, Tom, “Hadoop: The Definitive Guide”, United States, O'Reilly Media, 2012.
3. M. Parsian, “Data algorithms: Recipes for scaling up with Hadoop and Spark”
4. K. Hwang, M. Chen, “Big-Data Analytics for Cloud, IoT and Cognitive Computing”, Willey
5. Nikos Antonopoulos, Lee Gillam, "Cloud Computing: Principles, Systems and Applications", Springer.

ADDITIONAL BOOKS RECOMMENDED

1. Rajkumar Buyya, James Broberg, Andrzej M. Goscinski: "Cloud Computing: Principles and Paradigms", Wiley

Course Outcomes **At the end of the course, students will**	
CO1	have the knowledge of concepts, technologies, architecture and applications cloud computing and big data analytics.
CO2	be able to identify techniques achieving cloud based big data analytics with scalability and streaming capability.
CO3	be able to apply different algorithms and techniques of big data analytics using appropriate cloud platforms to solve complex problems.
CO4	be able to analyse and evaluate suitable cloud paradigm and big data analytics algorithms and techniques to give solutions for complex problems.
CO5	be able to design and give solutions for given problems through big data analytics tools and cloud platforms.

M. Tech. – I (CSE) ISP Semester – I	L	T	P	C
CSIS115: MACHINE LEARNING (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	to understand the basic concepts, state-of-the art techniques of machine learning, statistical analysis and discriminant functions
2	to study various supervised, unsupervised learning algorithms, classification, clustering, neural networks and different types of neural networks
3	to apply and analyze dimensionality reduction techniques
4	to understand and evaluate kernel methods to use them in various non-parametric approaches
5	to design an algorithm or optimum solution using different machine learning approaches

INTRODUCTION	**(09 Hours)**
Pattern Representation, Concept of Pattern Recognition and Classification, Feature Extraction, Feature Selection, Basics of Probability, Bayes Decision Theory, Maximum-Likelihood and Bayesian Parameter Estimation, Error Probabilities, Learning of Patterns, Modelling, Regression, Discriminant Functions, Linear Discriminant Functions, Decision Surface, Learning Theory, Fisher Discriminant Analysis.	
SUPERVISED LEARNING ALGORITHMS	**(09 Hours)**
Linear Regression, Gradient Descent, Support Vector Machines, Artificial Neural, Networks, Decision Trees, Ml and Map Estimates, K-Nearest Neighbor, Naïve Bayes, Bayesian Networks, Classification, Overfitting, Regularization, Multilayer Networks, Back-Propagation, Bayes Classification, Nearest Neighbor Classification, Cross Validation and Attribute Selection, K Means Clustering, Agglomerative Hierarchical Clustering, Deep Neural Networks, Convolutional Neural Networks, Recurrent Neural Networks.	
UNSUPERVISED LEARNING ALGORITHMS	**(09 Hours)**
K-Means Clustering, Gaussian Mixture Models, Learning with Partially Observable Data, Expectation Maximization Approach. Dimensionality Reduction, Principal Component Analysis, Model Selection and Feature Selection, Regularization, Theory of Generalization: in-Sample and Out-of-Sample Error, VCinequality, VC Analysis.	
NON PARAMETRIC APPROACH	**(08 Hours)**
Kernel Methods, Basic Kernels, Types of Kernel, Properties of Kernels, Pattern Analysis Using Eigen Decomposition, Principal Component Analysis, Hidden Markov Models, Markov Decision Processes, Non-parametric Techniques for Density Estimation, Parzen-Window Method.	
APPLICATIONS	**(10 Hours)**
Signal Processing Application, Image Processing, Biometric Recognition, Face and Speech Recognition, information Retrieval, Natural Language Processing.	
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

BOOKS RECOMMENDED

1. Richard O. Duda, Peter E. Hart, David G. Stork, “Pattern Classification”, 2nd Ed., Wiley, 2001.
2. Christopher M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2006.
3. Geoff Dougherty, “Pattern recognition and classification an introduction”, Springer, 2013.
4. Richard O. Duda and Peter E. Hart, “Pattern Classification and Scene Analysis”, John Wiley &

Sons, 1973.
5. John Shae Taylorand Nello Cristianini, "Kenerl methods for patten analysis" Cambaridge university press, 2004.

ADDITIONAL BOOKS RECOMMENDED

1. Ranjjan Shinghal, "Pattern Recognition techniques and application", Oxford university press, 2006.
2. Theodoridis and K.Koutroumbas, "Pattern Recognition", 4^{th} Ed., Academic Press, 2009.

Course Outcomes
At the end of the course, students will

CO1	have knowledge of pattern recognition, regression, classification, clustering algorithms and statistics.
CO2	be able to apply different feature extraction, classification, regression, neural network algorithms and modeling.
CO3	be able to analyze the data patterns and modeling for applying the learning algorithms and non-parametric approaches.
CO4	be able to evaluate the performance of an algorithm and comparison of different learning techniques.
CO5	be able to design solution for real life problems like biometric recognition, natural language processing and its related applications using various tools and techniques of machine learning.

M.Tech-I Semester – I	L	T	P	C
CSIS117: CYBER PHYSICAL SYSTEMS (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective:	
1	To have an understanding of the cyber physical systems and the corresponding important research challenges in this area.
2	To be able to learn the evolution in computing from mainframe computing to the ubiquitous and pervasive computing and the dominant role of the embedded systems.
3	To be able to understand various modelling formalisms for the CPSs, viz. Timed and Hybrid Automata and do the formal analysis using flow pipe construction, reachability analysis of CPS Software.
4	To be able to analyze and design the protocols used in resource constrained environments.
5	To be able to improve the critical reading, presentation, and research skills.

INTRODUCTION	**(04 Hours)**
Introduction to Cyber-Physical Systems. The Industrial Revolution 4.0. Motivation for the IR 4.0. Cyber-Physical Systems (CPS) in the real world.	
WIRELESS SENSOR NETWORK AND INTERNET OF THINGS	**(10 Hours)**
Basic principles of design and validation of CPS. Basic characteristics of the CPSs. The Internet of Things. The Industrial Internet of Things. The Wireless Sensor Networks and the RFID devices as the actors of the CPSs. The Ubiquitous and the Pervasive Computing paradigm introduced by the CPSs. The Applications of the Wireless Sensor Networks. The role of the Internet of Things in realizing Smart Applications. The Characteristics and the issues of deployment.	
CPS HARDWARE	**(09 Hours)**
CPS Hardware Platforms: Processors. Types of Processor. The Processors Design issues. Parallelism. Embedded Processors. Harvard Architecture: Pros and Cons. The Sensors and Actuators. Models of Sensors and Actuators. Common Sensors. Actuators. Memory Architectures. Memory Technologies. Memory Hierarchy. Memory Models. Types of memory in the CPSs. Input and Output Hardware. The design issues. The Analog to Digital convertor.	
CPS OPERATING SYSTEMS AND NETWORKING	**(09 Hours)**
Realtime Operating Systems for the WSN devices. Characteristics. Issues. Thread Scheduling. Basics of Scheduling. Rate Monotonic Scheduling. The Earliest Deadline First Scheduling. Scheduling and Mutual Exclusion. Multiprocessor Scheduling. Sequential Software in a Concurrent World. Multitasking. Imperative Programs. Case studies of the typical OSs. TinyOS, nesC and Contiki. The Simulators for the WSN devices. The CPS Network - WirelessHart, CAN, Automotive Ethernet.	
CPS MODELLING AND ANALYSIS	**(09 Hours)**
Formal Methods for Safety Assurance of Cyber-Physical Systems: Advanced Automata based modelling and analysis, Basic introduction and examples, Timed and Hybrid Automata, Definition of trajectories, Formal Analysis: Flow pipe construction, reachability analysis. Analysis of CPS Software: Weakest Preconditions, Bounded Model checking, CPS software verification: Frama-C, CBMC	
CPS SECURITY	**(04 Hours)**
Secure Deployment of CPS: Attack models, Secure Task mapping and Partitioning, State estimation for attack detection Automotive Case study: Vehicle ABS hacking Power Distribution Case study: Attacks on SmartGrids.	
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED

1. E. A. Lee and S. A. Seshia , " Introduction to Embedded Systems - A Cyber-Physical Systems Approach", Second Edition, The MIT Press, 2017.
2. Rajeev Alur,"Principles of Cyber-Physical Systems", The MIT Press. 2015
3. ZEADALLY S and Nafaâ Jabeur, "Cyber Physical System Design with Senor Networking Technologies, The IET Press. 2016.
4. Taha, W. M., Taha, A. M., Thunberg, J.,"Cyber-Physical Systems: A Model-Based Approach", Germany: Springer International Publishing, 2020
5. Rajkumar, R., de Niz, D., Klein, M, "Cyber-Physical Systems". United Kingdom: Pearson Education, 2016.

Course Outcomes **At the end of the course, students will be able to**	
CO1	Understand the fundamentals of cyber-physical systems (CPS).
CO2	Apply the concepts of CPS to the different paradigms of computing.
CO3	Analyze the design issues associated with different hardware functional units of the CPSs.
CO4	Evaluate the performance impact of thread scheduling algorithms in the CPSs.
CO5	Design CPS solutions for different application domains.

M. Tech. – I (CSE) ISP Semester – I	L	T	P	C
CSIS119: DIGITAL FORENSICS (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	To understand the basics of digital forensics and different cyber-crimes.
2	To identify the need of digital forensic and the role of digital evidence used to investigate the cyber-crime.
3	To understand the system activity logs to perform the scripting for investigating cyber-crime.
4	To investigate digital evidence such as the data acquisition, identification analysis and techniques for conducting the forensic examination on different digital devices.
5	To learn the various tools to perform the operations on data in order to assess the cyber crime

INTRODUCTION	**(06 Hours)**
Introduction to Digital Forensics, Definition and Types of Cybercrimes, Rules for Digital Forensic, Need for Digital Forensics, Types of Digital Forensics, Ethics in Digital Forensics, Introduction to Internet Crimes, Hacking and Cracking, Credit Card and ATM Frauds, Web Technology, Cryptography.	
CYBER CRIME AND DIGITAL EVIDENCES	**(08 Hours)**
Types of Digital Evidences and their Characteristics, Electronic Evidence and Handling, Challenges in Digital Evidence Handling, Searching and Storage of Electronic Media, Emerging Digital Crimes and Modules, Understanding Law Enforcement Agency Investigations, Following the Legal Process, Understanding Corporate Investigations, Establishing Company Policies.	
COMPUTER SECURITY INCIDENT RESPONSE	**(07 Hours)**
Introduction to Computer Security Incident, Goals of Incident Response, Incident Response Methodology, Formulating Response Strategy, Incident Response Process, Data Collection on Unix Based Systems.	
DISK AND FILE SYSTEM ANALYSIS	**(08 Hours)**
Media Analysis Concepts, File System Abstraction Model, Partition Identification and Recovery, Virtual Machine Disk Images, Forensic Containers Hashing, Carving, Forensic Imaging, Data Analysis Methodology, Investigating Applications, Malware Handling.	
IDENTIFICATION OF DATA	**(08 Hours)**
Identification of Data: Timekeeping, Forensic Identification and Analysis of Technical Surveillance Devices, Reconstructing Past Events, Useable File Formats, Unusable File Formats, Converting Files, Investigating Network Intrusions and Cyber Crime, Network Forensics and Investigating Logs, Investigating Network Traffic, Investigating Web Attacks, Router Forensics. Cyber Forensics Tools and Case Studies.	
NETWORK FORENSICS	**(08 Hours)**
Technical Exploits and Password Cracking, Analyzing Network Traffic, Collecting Network Based Evidence, Evidence Handling, Investigating Routers, Handling Router Table Manipulation Incidents, Using Routers As Response Tools.	
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

BOOKS RECOMMENDED
1. Jason Luttgens, Matthew Pepe, Kevin Mandia, "Incident Response and computer forensics", Tata McGraw Hill, 2014. 2. Nilakshi Jain, Dhananjay Kalbande, "Digital Forensic: The fascinating world of Digital Evidences", Wiley, 2016. 3. C. Altheide& H. Carvey, "Digital Forensics with Open Source Tools, Syngress", 2011. ISBN: 9781597495868. 4. Angus M.Marshall, "Digital forensics: Digital evidence in criminal investigation", John – Wiley and Sons, 2008. 5. Amelia Phillips, Bill Nelson, Christopher Steuart, "Guide to Computer Forensics and Investigations", Fourth Edition, Course Technology, 2009.

Course Outcomes **At the end of the course, students will**	
CO1	have the knowledge of various cybercrimes and the concepts of digital forensic, and handling evidence.
CO2	be able to apply appropriate response Strategy and the overall incidence response process.
CO3	be able to analyze the data and handling of malware.
CO4	be able to evaluate different evidence and methodologies for forensic analysis.
CO5	be able to design the digital forensic system to carry out system level forensics for cybercrimes.

M.Tech.I Semester – I	**L**	**T**	**P**	**C**
CSIS121: DEFENSIBLE SECURITY ARCHITECTURE (CORE ELECTIVE-1 OR 2)	**3**	**0**	**2**	**4**

Course Objective	
1	To learn the basic principles of traditional network and security architectures and analyse their common weaknesses.
2	To understand the design and architecture of defensible systems and networks.
3	To learn the fundamentals of traditional vs defensible security architectures, security models.
4	To be able to analyze and design an application to follow the defensible security architectures life cycle or DARIOM (Discover, Assess, Re-Design, Implement and Monitor) model.
5	To be able to design the application architecture ensuring that the application performs its operational functions effectively and security complements this goal.
6	To understand the principle of Time-Based Security and how to implement it in real world.

INTRODUCTION	**(10 Hours)**
Introduction: Course Overview, What is a Security Architecture? What makes a good Security Architect? Learning through Case (Tyrell Corp Case Study or any other to be selected). Traditional Security Architecture Deficiencies, Emphasis on Perimeter/Exploitation, Lack of a True Perimeter ("De-perimeterization" as a Result of Cloud/Mobile). The concept of Zero Trust and Defensible Security Architecture Mindset. The Presumption of Compromise De-perimeterization, The limitations of Think Red, Act Blue, approach. Overview of the Security Architectures in The Internet of Things.	
SECURITY MODELS	**(08 Hours)**
Security Models. Time Based Security. Cyber Kill Chain: Intelligence Driven Defense® model for identification and prevention of cyber intrusions. The Zero Trust Model, Zero Trust Architecture. Threat, Vulnerability, and Data Flow Analysis. Defensible Security Architecture Life Cycle (DARIOM Model). Threat Vector Analysis. Attack Surface Analysis. Physical Security Best Practices. Network Security Best Practices. Layer 2 Attacks and Mitigation. NetFlow for IP network traffic analysis. Layer 2 and 3 NetFlow. NetFlow, Sflow, Jflow, VPC Flow, Suricata and Endpoint Flow. Cloud Flows	
NETWORK SECURITY ARCHITECTURE	**(10 Hours)**
Network Security Architecture and Network-centric Applications Security Architecture: Layer 3 Attacks and Mitigation: IP Source Routing, ICMP Attacks, Unauthorized Routing Updates, Securing Routing Protocols, Unauthorized Tunneling (Wormhole Attack). Switch and Router Best Practices: Layer 2 and 3 Benchmarks and Auditing Tools. Baselines. Securing SNMP. Hardening SNMP. Securing NTP. Bogon Filtering, Blackholes, and Darknets. Bogon Filtering. Monitoring Darknet Traffic. Securing IPv6: IPv6 Firewall Support, Scanning IPv6, IPv6 Asset Inventory with Rumble Network Discovery, IPv6 Tunneling, IPv6 Router Advertisement Attacks and Mitigation. Segmentation: Network vs Access Segmentation. Firewall Architecture: DMZ Design, Layer 3/4 Stateful Firewalls, Router ACLs, Linux and BSD Firewalls. Azure Privileged Management (PIM). Application Proxies. SMTP Proxy. Augmenting with Phishing Protection and Detection Mechanisms. Next-Generation Firewall: (NGFW): Application Filtering, Implementation Strategies. Network Security Monitoring (NSM). NIDS/NIPS. Sandboxing. The "Encrypt Everything" Mindset. HSTS Preloading. Certificate Transparency Monitoring. Crypto Suite Support. Distributed Denial-of-Service Protection. Impact of Internet of Things. Types of Attacks. Mitigation Techniques	
DATA-CENTRIC SECURITY ARCHITECTURES	**(08 Hours)**
Data-centric Security architecture. Application (Reverse) Proxies. Full Stack Security Design. Web Application Firewalls. Database Firewalls/Database Activity Monitoring. File Classification Data Discovery. Dynamic Access Control. Data Loss Prevention (DLP): Network-based, Endpoint-based,	

Cloud Application Implementations. Data Governance, Mobile Device Management (MDM) and Mobile Application Management (MAM). Security Policies. Private Cloud Security. Public Cloud Security Challenges. Container Security	
ZERO TRUST ARCHITECTURES	**(09 Hours)**
Zero Trust Architectures: Why Perimeter Security Is Insufficient? What Zero Trust Architecture Means. "Trust but Verify" vs. "Verify then Trust". Credential Rotation. Adaptive Trust and Security Orchestration. Authenticating and Encrypting Endpoint Traffic. Domain Isolation (Making Endpoint Invisible to Unauthorized Parties). Mutual TLS. Segmentation Gateways. Leveraging Endpoints as Hardened Security Sensors. End-user Privilege Reduction. Scaling Endpoint Log Collection/Storage/Analysis: How to Enable Logs that Matter, Designing for Analysis Rather than Log Collection, Auditing Policies on Windows and Linux: Sysmon, Auditd. Tripwire and Red Herring Defenses: Honeynets, Honeypots, and Honeytokens, Single Access Detection Techniques, Proactive Defenses to Change Attacker Tool Behaviors, Increasing Prevention Capabilities while Adding Solid Detection.	
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED

1. Ed Moyle (Author), Diana Kelley , “Practical Cybersecurity Architecture: A guide to creating and implementing robust designs for cybersecurity architects”, Packt Publishing Limited, 2020.
2. Heather Adkins, Betsy Beyer, Paul Blankinship, Piotr Lewandowski, Ana Opera and Adam Stubblefield , “Building Secure & Reliable Systems: Best Practices for Designing, Implementing and Maintaining Systems”, O’Reilly Shroff Publishers, 2020.
3. Evan Gilman, Doug Barth , “Zero Trust Networks: Building Secure Systems in Untrusted Networks Paperback – 1”, O’Reilly Shroff Publishers, 2017.
4. Chris Dotson ,“Practical Cloud Security: A Guide for Secure Design and Deployment 2019”, O’Reilly Shroff Publishers, 2017.
5. Jason Garbis, Jerry W. Chapman , “Zero Trust Security: An Enterprise Guide Paperback”, Apress Publishers, 1st edition, 2021.

Course Outcomes
At the end of the course, students will able to

CO1	Learn the basic principles of traditional network and security architectures.
CO2	Analyse the common weaknesses of the traditional security architectures and understand the significance of the defensible security architectures.
CO3	Build and design models of the defensible systems and networks.
CO4	Analyze and design an application to follow the defensible security architectures life cycle or DARIOM (Discover, Assess, Re-Design, Implement and Monitor) model.
CO5	Design the application architecture ensuring that the application performs its operational functions effectively and security complements this goal.
CO6	Understand the principle of Time-Based Security and how to implement it in real world.

M. Tech. – I (CSE) ISP Semester – I	L	T	P	C
CSIS123: RESEARCH METHODOLOGY IN CSE (CORE ELECTIVE-1 OR 2)	**3**	**1**	**0**	**4**

Course Objective	
1	To understand the basic terminology of research, its methodology and learn different methodologies of pursuing the research in terms of organization, presentation and evaluation.
2	To apply the concept in writing the technical content.
3	To analyze the existing method using different parameters in different scenarios.
4	To evaluate the proposed work and compare with existing approaches systematically using the appropriate methodology, through simulation depending upon the research field.
5	To design algorithms using concepts learned and write reports and papers technically and grammatically correct.

INTRODUCTION	**(04 Hours)**
Research: Definition, Characteristics, Motivation and Objective, Research Methods vs Methodology, Types of Research – Descriptive vs Analytical, Applied vs Fundamental, Quantitative vs Qualitative, Conceptual vs Empirical.	
METHODOLOGY	**(04 Hours)**
Research Process, Formulating the Research Problem, Defining the Research Problem, Research Questions, Research Methods vs. Research Methodology.	
LITERATURE REVIEW	**(04 Hours)**
Review Concepts and Theories, Identifying and Analyzing the Limitations of Different Approaches.	
FORMULATION AND DESIGN	**(05 Hours)**
Concept and Importance in Research, Features of a Good Research Design, Exploratory Research Design, Concept, Types and Uses, Descriptive Research Designs, Concept, Types and Uses, Experimental Design: Concept of Independent & Dependent Variables.	
DATA MODELING AND SIMULATIONS	**(08 Hours)**
Mathematical Modeling, Experimental Skills, Simulation Skills, Data Analysis and Interpretation.	
TECHNICAL WRITING AND TECHNICAL PRESENTATIONS	**(05 Hours)**
CREATIVITY AND ETHICS IN RESEARCH, INTELLECTUAL PROPERTY RIGHTS	**(05 Hours)**
TOOLS AND TECHNIQUES FOR RESEARCH	**(06 Hours)**
Methods to Search Required Information Effectively, Reference Management Software, Software for Paper Formatting, Software for Detection of Plagiarism.	
DISCUSSION AND DEMONSTRATION OF BEST PRACTICES	**(04 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)

BOOKS RECOMMENDED

1. John W. Creswell, “Research Design: Qualitative, Quantitative, and Mixed Methods Approaches”, SAGE Publications Ltd.
2. C.R. Kothari,”Research Methodology: Methods and Techniques”, New Age International Publishers.
3. David Silverman,”Qualitative Research”, SAGE Publications Ltd.
4. Norman K. Denzin and Yvonna Sessions Lincoln,”Handbook of Qualitative Research”, SAGE Publications Ltd.
5. Michael Quinn Patton, ”Qualitative Research and Evaluation Methods”, SAGE Publications Ltd.

Course Outcomes **At the end of the course, students will**	
CO1	have an understanding of the different research methodology in different areas.
CO2	be able to apply the concepts in writing, presentation, and simulating different experiments.
CO3	be able to analyze the proposed work with existing approaches in the literature and interpret the research design through project development and case study analysis using appropriate tools.
CO4	be able to execute the technical presentation, organization in writing the report and papers.
CO5	be able to design the algorithms and proof learned and communicate effectively through proper organization and presentation.

M. Tech. – I (CSE) ISP Semester – II	L	T	P	C
CSIS125: BLOCKCHAIN FUNDAMENTALS AND USE CASES (CORE ELECTIVE-3 OR 4)	**3**	**0**	**2**	**4**

Course Objective	
1	to demonstrate a familiarity with the concepts related to blockchain technology.
2	to apply the knowledge of cryptography and distributed systems to design decentralized applications.
2	to design and build smart contracts and distributed applications (DApps) for different applications.
3	to analyse and explore the real-world applications of blockchain technology.
4	to assess the strengths and weaknesses of blockchain enabled decentralization in different application scenarios.

INTRODUCTION	**(08 Hours)**
Introduction to Blockchain and Digital Currency, Evolution, Blockchain as Public ledger, Structure of a Block, Transactions, Merkel Trees, Peer-to-Peer Networks, Timestamp, Double Spend Problem, Decentralization Applications, Characteristics, Benefits and Challenges.	
CRYPTOGRAPHY IN BLOCKCHAIN	**(08 Hours)**
Hash Functions, Public Key Cryptosystem, Public Key Generation, Digital Signature, Zero-Knowledge Proof, k-Anonymity.	
SMART CONTRACTS AND CONSENSUS ALGORITHMS	**(05 Hours)**
Smart Contract, Applications of Smart Contracts, Mining, Hardness of Mining, Incentive, Consensus, Paxos, Consensus Algorithms - PBFT, PoW, PoS, etc.	
DISTRIBUTED COMPUTING IN BLOCKCHAIN	**(07 Hours)**
Distributed System, Multi-Party Consensus Algorithm, Distributed Denial of Service (DDoS), Secure Multiparty Computation, Byzantine Generals Problem, Byzantine Fault Tolerance based and Leader-based Consensus Mechanism, CAP Theorem, Client-Server Model, Virtual Machines- Ethereum Virtual Machine (EVM) and Tron Virtual Machine (TVM), Quorum Systems, DApps.	
ETHEREUM AND HYPERLEDGER	**(07 Hours)**
Ethereum, Trustlessness and Immutability of Blockchain Technology, Proof of Work (PoW) andProof of Stake (PoS), Ethereum Virtual Machine (EVM), Wallets for Ethereum, Solidity, Hyperledger, Corda, Hyperledger Fabric, Hyperledger Composer, Permissioned vs Permissionless Blockchain.	
BLOCKCHAIN FOR REAL-WORLD APPLICATIONS	**(06 Hours)**
Cryptocurrencies, Banking, Supply Chain, Healthcare, Real-Estate, Judiciary, IoT, Insurance, etc.	
ADVANCED TOPICS	**(04 Hours)**
Pool Mining, Sybil Attacks, Scalability of Blockchain, Smart Contract Vulnerabilities, Finalizing Transaction, Privacy Leakage. Note: topics Will Be Revised Time to Time According to Advancement and Trends in Technology.	
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

BOOKS RECOMMENDED

1. Arvind Narayanan, Joseph Bonneau, Edward Felten, andrew Miller, Steven Goldfeder, “Bitcoin and Cryptocurrency Technologies: A Comprehensive introduction”, Princeton University Press, 2016.
2. Roger Wattenhofer, “Blockchain Science: Distributed Ledger Technology”, independently Published, ISBN-10 : 1793471738, 2019.

3. Andreas M. Antonopoulos, “Mastering Bitcoin: Programming the Open Blockchain”, Shroff/O'Reilly, 2017.
4. Elaine Shi, “Foundations of Distributed Consensus and Blockchains”, (URL: http://elaineshi.com/docs/blockchain-book.pdf), 2020.
5. Alan T. Norman, “Blockchain Technology Explained: the Ultimate Beginner s Guide About Blockchain Wallet, Mining, Bitcoin, Ethereum, Litecoin, Zcash, Monero, Ripple, Dash, IOTA and Smart Contracts”, Amazon Digital Services, 2017.

ADDITIONAL BOOKS RECOMMENDED

1. Bahga, Arshdeep, and Vijay Madisetti. "Blockchain applications: a hands-on approach", VPT, 2017.

Course Outcomes **At the end of the course, students will**	
CO1	have knowledge about the design principles of blockchain and smart contracts.
CO2	be able to program and demonstrate the working of different consensus mechanisms.
CO3	be able to deploy and interact with blockchain systems by setting up a system and sending and reading the transactions.
CO4	be able to design, build, and deploy distributed applications and smart contracts by identifying the need of blockchains to find the solution to the real-world problems.
CO5	be able to evaluate security, privacy, and efficiency of a given blockchain use case.
CO6	have knowledge about the challenges related to blockchain and smart contracts.

M. Tech. – I (CSE) ISP Semester – II	L	T	P	C
CSIS112: MACHINE LEARNING FOR SECURITY (CORE ELECTIVE-3 OR 4)	**3**	**0**	**2**	**4**

Course Objective	
1	to describe the fundamental concepts of machine learning for devising security mechanisms.
2	to enumerate the techniques for intrusion detection and malware detection and analysis using machine learning.
3	to learn the machine learning techniques for network traffic analysis
4	to analyse the machine learning approaches for security for probable abuse by the adversary.
5	to design secure machine learning based schemes for malware detection and intrusion detection.

INTRODUCTION & REVIEW OF THE MACHINE LEARNING BASICS	**(04 Hours)**
Review of the basic concepts in Linear Algebra, Probability and Statistics. Introduction to the ML techniques. Machine Learning problems viz. Classification, Regression, Clustering, Association rule learning, Structured output, Ranking. The Supervised and Unsupervised learning algorithms. Linear Regression, Gradient descent for convex functions, Logistics Regression and Bayesian Classification Support Vector Machines, Decision Tree and Random Forest, Neural Networks, DNNs , Ensemble learning. Principal Components Analysis. Un-supervised learning algorithms: K-means for clustering problems, K-NN (k nearest neighbors). Apriori algorithm for association rule learning problems. Generative vs Discriminative learning. Empirical Risk Minimization, loss functions, VC dimension. Data partitioning (Train/test/Validation), cross-validation, Biases and Variances, Regularization.	
MACHINE LEARNING FOR SECURITY	**(05 Hours)**
Introduction to Information Assurance. Review of Cybersecurity Solutions: Proactive Security Solutions, Reactive Security Solutions: Misuse/Signature Detection, Anomaly Detection, Hybrid Detection, Scan Detection. Profiling Modules. Understanding the Fundamental Problems of Machine-Learning Methods in Cybersecurity. Incremental Learning in Cyberinfrastructures. Feature Selection/Extraction for Data with Evolving Characteristics. Privacy-Preserving Data Mining. Motivation for ML in security with real-world case studies. Topics of interest in applications of machine learning for security.	
MACHINE LEARNING TECHNIQUES FOR INTRUSION DETECTION	**(08 Hours)**
Emerging Challenges in Cyber Security for Intrusion Detection: Unifying the Current Anomaly Detection Systems, Network Traffic Anomaly Detection. Imbalanced Learning Problem and Advanced Evaluation Metrics for IDS. Reliable Evaluation Data Sets or Data Generation Tools. Privacy Issues in Network Anomaly Detection. Machine Learning Techniques: for Anomaly Detection, for Misuse/Signature detection, for Hybrid detection, for Scan detection.Cost-Sensitive Modeling for Intrusion Detection. Data Cleaning and Enriched Representations for Anomaly Detection in System Calls.	
MACHINE LEARNING TECHNQIUES FOR MALWARE ANALYSIS	**(08 Hours)**
Emerging Cyber Threats in malwares: Threats from Malware, Botnets, Cyber Warfare, Mobile Communication. Cyber Crimes. Malware Analysis: Feature generation, Features to Classification. Taxonomy of malware analysis approaches based on machine learning. Malware Detection, Similarity Analysis, Category Detection. Feature Extraction. PE Features. Supervised, Unsupervised and Semi-supervised learning algorithms for Malware Detection. Using Deep Learning Approaches: Generative Adversarial Networks.	
NETWORK TRAFFIC ANALYSIS & WEB ABUSE DETECTION	**(08 Hours)**

Machine Learning for Profiling Network Traffic: Theory of Network defense (access control, authentication, detecting in-network attackers, data-centric security, honeypots), Predictive model for classifying network attacks.	
MACHINE LEARNING IN PRIVACY PRESERVATION	**(06 Hours)**
k-anonymity; l-diversity; deferentially private data storage/release; verifiable differential privacy; privacy-preserving inference of social networking data; privacy-preserving recommender system; privacy versus utility. Machine learning techniques for Privacy Preserving Data Mining.	
ADVERSARIAL MACHINE LEARNING	**(06 Hours)**
Adversarial Machine Learning: Motivation and Background. Practical Scenarios and Examples. Modelling the Adversary: Attack Surface Adversary Goals Adversary capabilities. Taxonomy of Adversarial Attacks on Machine Learning: Influence Specificity Security Violation. Data poisoning; Perturbation; Defense mechanism; Generative Adversarial Networks. A peep into Industry Perspectives: Theme of inference Secure Software Development Life Cycle or Secure Development Cycle. Key Inferences in terms of Security gaps, Suggested panacea.	
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED

1. Clarence Chio, David Freeman., “Machine Learning and Security. Protecting Systems with Data and Algorithms”, O’Reilly Media Publications, 2018.
2. Marcus A. Maloof (Ed.) , “Machine Learning and Data Mining for Computer Security: Methods and Applications”, Springer-Verlag London Limited, 2006.
3. Sumeet Dua and Xian Du, “Data Mining and Machine Learning in Cybersecurity”. CRC Press, Taylor and Francis Group, LLC. 2011.
4. Research Papers Prescribed in the class.
5. Fei Hu, Xiali Hei, “AI, Machine Learning and Deep Learning: A Security Perspective”, United States: CRC Press, 2023.

Course Outcomes **At the end of the course, students will**	
CO1	have a knowledge of the limitations of the conventional security software in the wake of machine learning based attacks on the security software
CO2	be able to apply the concepts machine learning based intrusion detection to analyze the IDSs.
CO3	be able to analyze the malware analysis and mitigation based solutions for the probable threats therein.
CO4	be able to design the threat models based on machine learning approaches for network analysis.
CO5	be able to use the concepts of machine learning to prevent security design faults.

M. Tech. – I (CSE) ISP Semester – II	L	T	P	C
CSIS118: SOFTWARE SECURITY (CORE ELECTIVE-3 OR 4)	**3**	**0**	**2**	**4**

Course Objective	
1	to discuss and explain the fundamental concepts of software security and defensive programming.
2	to enumerate the vulnerabilities in a typical memory unsafe language and the potential attacks/exploits.
3	to learn counter mechanisms for preventing the security vulnerabilities from being exploited and those for ensuring secure programs.
4	to analyse the limits of the applicability of the sast tools as well as the dast tools.
5	to design a program free from the known vulnerabilities as well as to withstand the zero-day vulnerabilities.
6	to apply the skills learnt to generate secure programs.

INTRODUCTION	**(02 hours)**
Introduction to the course. Review of Information Security concepts. The CIA Triad. Systems Security, Information Security, Application Security, Network Security – commonalities and differences. Essential Terminologies. Proactive software security vis-à-vis the security software. The concept of Software Security. Security in Software Development Life Cycle. Security as a Software Quality attribute. The trinity of troubles viz. Connectivity, Extensibility and Complexity. Studies of various catastrophes due to Insecure software. Model Based Security Engineering, Three Pillars of Software Security. Security in Software Lifecycle. The basic terminologies: a bug, an exploit, a threat, defects, vulnerabilities, risks, attacks.	
SECURITY ATTACKS AND TAXONOMY OF SECURITY ATTACKS	**(02 Hours)**
Review of security attacks – Taxonomy of Security Attacks, Methods. Attacks in each phase of software life cycle. Attacks on the TCP/IP protocol suite layers. Motivation for attackers, Methods for attacks: Malicious code, Hidden software mechanisms, Social Engineering attacks, Physical attacks. Non-malicious dangers to software. Attacks in each phase of software life cycle. Security Vulnerabilities and Attack Taxonomy in Internet of Things and Cyber Physical Systems. Review of Malwares: Viruses, Trojans, and Worms. Malware Terminology: Rootkits, Trapdoors, Botnets, Key loggers, Honeypots. IP Spoofing, Tear drop, DoS, DDoS attacks.	
THE SECURITY VULNERABILITIES - I	**(10 Hours)**
The Software Vulnerabilities: Vulnerabilities in the Memory-safe and memory-unsafe languages. Introduction to the Program Stack Analysis. Hands-on on Stack Analysis using gcc compiler and gdb debugger tool. Methods of security attack exploiting the vulnerabilities in the code. Taxonomy of security vulnerabilities. Remote Code Execution. State-of-the-art in research in Security Vulnerabilities. Overview of C, C++, Java Security Vulnerabilities. The common Web vulnerabilities: the Buffer Overflow - Stack overflows, Heap Overflows, the Code and Command Injections and the types: SQL injection, Cross-site scripting, Interpreter injection; the Format String vulnerabilities, writing shellcode. The Seven Pernicious Kingdoms. The Hidden form fields, Weak session cookies. Fault injection & Fault monitoring, Fail open authentication The OWASP Top 25 vulnerabilities in the current year.	
CODE REVIEWS AND STATIC ANALYSIS OF THE SOURCE CODE	**(08 Hours)**
Introduction to Code reviews and Static Informal reviews, Formal inspections. Illustrations. Introduction to Code reviews and Static Analysis. Code Reviews. Static Code Analysis. Static and Dynamic Application	

Security Testing (SAST and DAST) tools. Using basic linting to detect security vulnerabilities in the code with the linux find(), grep(), awk(), splint() and the FlawFinder. A glance at Code Analyzer Tools : Top-10: Raxis, SonarQube for Code Quality and Code Security, PVS-Studio, reshift, Embold, SmartBear Collaborator, CodeScene Behavioral Code Analysis, RIPS Technologies. Others: Cscope, Ctags, Editors, Cbrowser	
THE SECURITY VULNERABILITIES – II	**(09 Hours)**
Introduction to Session Management in Web Applications. Session Management best practices. The XSRF (Cross-site Request Forgery) Attack. Security vulnerabilities in Java: Connection String Injection, LDAP Injection, Reflected XSS, Resource Injection, Persistent XSS attacks in Java, The XPath Injection. Insecure deserialization, Remote code execution (RCE). Log injection. Mail injection. Vulnerabilities in Java libraries. Vulnerabilities in the Java sandboxing mechanism. Insufficient Transport Layer Protection (ITLP). Application misconfiguration and Software Composition Analysis (SCA).	
THREAT MODELLING	**(10 Hours)**
Finding Threats: Using STRIDE, Attack Patterns, Attack Trees, Misuse Patterns. Threat modelling with Attack Trees and Graphs. Anti-models. State transition diagrams. Access control models. Specifying Secrecy, Authentication and Assertions. Graph based specifications, UML-based specifications. Formal Security specifications. Web Threats, Cloud Threats, Mobile Threats, Threats to Cyrptosystems. Attack Libraries: Properties, OWASP Top Ten, CAPEC. Privacy Tools: Solove's Taxonomy of Privacy, Privacy Considerations for Internet Protocols, Privacy Impact Assessments (PIA), The Nymity Slider and the Privacy Ratchet, Contextual Integrity, LINDDUN. Threat Modeling tools: Whitebiards, Office-suites, Bug-tracking systems, TRIKE, Sea-monster, Elevation-of-privilege, Threat Modeler, Microsoft's SDL Threat Modeling Tool. When to Threat Model, What to model, Scenario-Specific Elements of Threat Modeling. Automated Threat Modeling, Threat modeling with code.	
DYNAMIC APPLICATION SECURITY TESTING	**(04 Hours)**
Basics, Approaches to DAST, DAST application analysis. DAST prerequisites. DAST job order, DAST run options. Tools, DAST Pros and Cons. DAST in DevOps practices. Interactive application security testing (IAST), Software composition analysis (SCA).	
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

BOOKS RECOMMENDED

1. Michael Howard, David LeBlanc, “Writing Secure Code”, Microsoft Press, 2nd Edition. 2004.
2. McConnell Steve, “Code Complete (Developer Best Practices)”, Kindle Edition, Microsoft Press, 2nd Edition. 2004.
3. Edward Skoudis, Tom Liston, “Counter Hack Reloaded: A Step-by-Step Guide to Computer Attacks and Effective Defences”, Prentice Hall.
4. Mark G. Graff, Kenneth R.VanWyk, “Secure Coding: Principles and Practices”, O'Reilly Media.
5. Gary McGraw, “Software Security: Building Security In”, Addison-Wesley.

ADDITIONAL BOOKS RECOMMENDED

1. Stuart McClure, Joel Scambray, George Kurtz , “Hacking Exposed 7: Network Security Secrets & Solutions”, McGraw-Hill Osborne Media.

Course Outcomes At the end of the course, students will	
CO1	have a knowledge of the basic concepts and problems of memory unsafe and memory safe languages
CO2	be able to use the concepts to detect security vulnerabilities and prevent them.
CO3	be able to analyze/interpret program code for doing Static and Dynamic Security Testing.
CO4	be able to design the new software with the security features builtin rather than reliance on the security software.
CO5	be able to use the concepts of information security to prevent security design faults.

M. Tech. – I (CSE) ISP Semester – II	L	T	P	C
CSIS120: SECURITY AND PRIVACY IN THE RESOURCE CONSTRAINED ENVIRONMENTS (CORE ELECTIVE-3 OR 4)	3	0	2	4

Course Objective	
1	to be able to understand the concept of resource constrained devices, their characteristics, their applications and the constraints under which they operate.
2	to be able to understand the importance of the security issues in embedded devices/systems, with wireless sensor networks (wsns) and the internet of things (iot) as the case studies.
3	to be able to understand the wireless sensor networks, the typical configurations of the constituent components viz. sensor motes, typical applications, operating environments, programming languages, simulators through demonstrations.
4	to be able to analyze the security vulnerabilities with respect to various denial of service attacks at the network layer in wsns as well as that in the routing protocols for the manets.
5	to be able to analyze the design of a typical link layer security architecture for wsns and the design of the light weight ciphers for the wsns.
6.	to be able to design the security mechanisms suitable for wsns viz. the iv, mac, replay protection algorithm, key deployment algorithm for the hop-by-hop as well as end-to-end secure data aggregation protocols.
7.	to be able to analyze the advanced key management techniques viz. attribute based encryption, identity based encryption, function encryption and their applications.

INTRODUCTION	**(03 Hours)**
Review of the Network Security Concerns. Fundamental Network Security Threats. Types of Network Security Threats. Network Security Vulnerabilities, their types: Technological Vulnerabilities, Configuration Vulnerabilities, Security policy Vulnerabilities. Types of Network Security Attacks.	
UBIQUITOUS AND PERVASIVE COMPUTING PARADIGM EMBEDDED SECURITY	**(06 Hours)**
Introduction to ubiquitous and pervasive computing paradigm, Embedded systems, Wireless Sensor Nodes as representative Embedded Systems, Wireless Sensor Networks (WSNs), Typical configurations, Typical Applications of the WSNs. Case studies of real world applications. Deployment models, Characteristics, Security Issues in Wireless Sensor Networks, Typical Attacks and Countermeasures.	
SECURE DATA AGGREGATION	**(12 Hours)**
The Concept of In Network processing and Data Aggregation. Motivation for the Link Layer Security architecture in Wireless Sensor Networks. Design Issues for Link Layer Security in Wireless Sensor Networks. Case studies of the hop-by-hop security architectures viz. TinySec, MiniSec, FlexiSec. Use of TOSSIM, Avrora or any other appropriate simulator. End-to-end security architecture for Wireless Sensor Networks.	
END-TO-END SECURE DATA AGGREGATION & ALGORITHMS	**(12 Hours)**
Use of Partial Homomorphic Encryption Algorithms – Case studies. Additive and Multiplicative Homomorphic Encryption algorithms. Robustness and Resilient Concealed Data Aggregation: Different approaches to offer data integrity viz. using conventional MAC - Aggregate MAC, Homomorphic MAC, Hybrid Secure Data Aggregation. Malleability Resilient Concealed Data Aggregation	
SECURITY OF THE ROUTING PROTOCOLS IN MANETS	**(02 Hours)**
Routing Protocols for MANETS, Their Security Vulnerabilities, Typical Solutions. Security of the AODV protocol – typical mitigation to counter Black-hole attacks ON AODV.	

THE KEY MANAGEMENT IN THE EMBEDDED SYSTEMS	**(04 Hours)**
Public Key Infrastructure in Wireless Sensor Networks, The TinyPK protocol as a case study. Public Key Infrastructure in Wireless Sensor Networks, The Merkle-Hellman tree based approach for key validation. Attribute Based Encryption and its motivation for Embedded Systems. Identity-based encryption and Functional encryption, motivation and case studies.	
THE TINY CIPHERS	**(02 Hours)**
Design of the STATE OF THE ART tiny ciphers for the tiny devices and the RFID devices: TEA, XTEA, XXTEA, KTANTAN, mCrypton etc.	
THE INTERNET OF THINGS SECURITY	**(04 Hours)**
The Internet of Things. Architecture. Constituent Elements. The Security and Privacy Issues in IoT Systems. Overview of the IoT Protocols. Security of the RPL protocol. The IoT Security Protocols viz. ZigBee, Bluetooth, 6LowPAN, RPL. The CoAP.	
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED
1. The research papers prescribed in the class.

Course Outcomes: **At the end of the course, students will be able**	
CO1	to understand the concept of resource constrained devices, their characteristics, their applications and the constraints under which they operate.
CO2	to apply the security mechanism for resource constraints environments and identify the security vulnerabilities with respect to various Denial of Service attacks at the Network Layer in WSNs as well as that in the Routing protocols for the MANETs.
CO3	to analyze the design of a typical link layer security architecture for WSNs and the design of the light weight ciphers for the WSNs.
CO4	to evaluate the advanced key management techniques viz. Attribute Based Encryption, Identity Based Encryption, Function Encryption and their applications
CO5	to design the security mechanisms suitable for WSNs viz. the IV, MAC, replay protection algorithm, key deployment algorithm for the hop-by-hop as well as end-to-end Secure Data Aggregation protocols.

M. Tech. – I (CSE) ISP Semester – II	L	T	P	C
CSIS122: SECURITY AND PRIVACY IN SOCIAL NETWORKS (CORE ELECTIVE-3 OR 4)	**3**	**0**	**2**	**4**

Course Objective	
1	to understand online social media privacy and security issues.
2	to recognize different privacy and security problems on online social media (spam, phishing, fraud nodes, and identity theft).
3	to use online social networks to express a wide range of problems.
4	to use the analysis of security issues and countermeasures to create new knowledge, decisions, and actions.
5	to solve identity problems with understanding of location based privacy.

INTRODUCTION TO SOCIAL NETWORKS SECURITY	**(06 Hours)**
Types and Classification of Social Media, Problems and Opportunities of Social Media- Risks of Social Media, Public Embarrassment, False Information, Information Leakage, Retention and Archiving Content, Backing Up Social Media, Loss of Data/Equipment, Dark Side of Social Media, Cybercrime, Social Engineering, Hacked Accounts; Sharing Information on Social Media.	
ATTACKS ON SOCIAL MEDIA AND DATA ANALYTICS SOLUTIONS	**(06 Hours)**
Malware and Attacks, Types of Malware, Threats to Cyber Security, Attacks on Social Media, Data Analytics Solutions, Data Mining for Cyber Security, Malware Detection as a Data Stream Classification Problem, Cloud-Based Malware Detection for Evolving Data Streams, Cloud Computing for Malware Detection, Design and Implementation of the System Ensemble Construction and Updating, Malicious Code Detection.	
CONFIDENTIALITY, ACCESS CONTROL, PRIVACY AND TRUST IN SOCIAL MEDIA	**(08 Hours)**
CPT Framework and Process, Inference Engines, Confidentiality Management, Privacy for Social Networks, Trust for Social Networks, Security Policies for Social Networks, Access Control System for Social Networks	
INFERENCE CONTROL FOR SOCIAL MEDIA	**(06 Hours)**
Architecture and Design of an Inference Controller, Inference Control through Query Modification - Query Modification, Query Modification With Relational Data, Sparql Query Modification, Query Modification for Enforcing Constraints, Applications, Use Cases of Inference Controller.	
SECURE QUERY PROCESSING FOR SOCIAL MEDIA	**(06 Hours)**
Secure Cloud Query Processing with Relational Data for Social Media, Secure Cloud Query Processing for Semantic Web-Based Social Media - Access Control and System Architecture.	
SOCIAL NETWORK INTEGRATION AND ANALYSIS WITH PRIVACY PRESERVATION	**(09 Hours)**
Social Network Analysis, Limitations of Current Approaches for Privacy-Preserving Social Networks - Privacy Preservation of Relational Data, K-Anonymity and L-Diversity, Privacy Preservation of Social Network Data, Framework of Information Sharing and Privacy Preservation For Integrating Social Networks - Sharing Insensitive Information, Generalization, Probabilistic Model of Generalized Information, Integrating Generalized Social Network For Social Network Analysis Task.	
Advanced Topics	**(04 Hours)**
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

BOOKS RECOMMENDED

1. Thuraisingham B., Abrol Raymond Heatherly S., Kantarcioglu M., Khadilkar V., Khan L, “Analyzing and Securing Social Networks”, Taylor & Francis Group, 2016.
2. Michael Cross, “Social Media Security”, Elsevier, 2013
3. Altshuler Y., Elovici Y., Cremers A.B., AharonyN., Pentland, “Security and Privacy in Social Networks”, Springer, 2013.
4. Gavin Bell, “Building Social Web Applications”,O’Reilly, 2009.
5. Carminati, B., Ferrari, E., Viviani, M, “ Security and Trust in Online Social Networks” , Switzerland: Morgan & Claypool Publishers, 2013.

Course Outcomes **At the end of the course, students will**	
CO1	be able to understand various privacy and security risks (spam, phishing, fraud nodes, identity theft).
CO2	be able to apply the appropriate analytical methodology for fresh research and evaluate the results accurately.
CO3	be able to analyse fraudulent entities in online social networks.
CO4	be able to evaluate algorithms for handling various concerns comprehensively on online Social Media.
CO5	be able to design the system addressing various privacy issues of frameworks to relate them to techniques and applications.

M. Tech. – I (CSE) ISP Semester – II	L	T	P	C
CSIS126: ADVERSARIAL MACHINE LEARNING (CORE ELECTIVE-3 OR 4)	**3**	**0**	**2**	**4**

Course Objective	
1	to be able to understand the concept of trustworthy machine learning.
2	to be able to understand various types of attacks and defences in adversarial machine learning.
3	to be able to understand the issues faced by the applications using machine learning.
4	to be able to analyze the relationship between the information leakage and privacy.
5	to be able to analyze and do research while learning about adversarial machine learning.

INTRODUCTION	**(03 Hours)**
Introduction, Background, review of the concepts of machine learning for security. Motivation for studying Adversarial Machine Learning through various case studies.	
ADVERSARIAL LEARNING	**(05 Hours)**
Adversarial Classification, Adversarial Learning, Generative Adversarial Networks.	
PRIVACY ATTACKS (ADVERSARIAL EXAMPLES) & COUNTER MECHANISMS	**(10 Hours)**
Stealing Machine Learning Models via Prediction APIs, Model Reconstruction from Model Explanations, Membership Inference Attacks Against Machine Learning Models. Counter Mechanisms: Machine Learning with Membership Privacy using Adversarial Regularization. Privacy-preserving Prediction. Deep Learning with Differential Privacy	
POISONING ATTACKS (ADVERSARIAL EXAMPLES) & COUNTER MECHANISMS	**(10 Hours)**
Poisoning Attacks, Poisoning Attacks against Support Vector Machines, Poison Frogs, Targeted Clean-Label Poisoning Attacks on Neural Networks, Stronger Data Poisoning Attacks Break Data Sanitization Defenses, Transferable Clean-Label Poisoning Attacks on Deep Neural Nets. Counter mechanisms.Certified Defenses for Data Poisoning Attacks. Robust Training of Deep Neural Networks with Extremely Noisy Labels. Robust Logistic Regression and Classification.	
EVASION ATTACKS (ADVERSARIAL EXAMPLES) & COUNTER MECHANISMS	**(10 Hours)**
Explaining and Harnessing Adversarial Examples. Towards Evaluating the Robustness of Neural Networks Why Do Adversarial Attacks Transfer? Explaining Transferability of Evasion and Poisoning Attacks.	
ADVANCED ADVERSARIAL ATTACKS & COUNTER MECHANISMS	**(07 Hours)**
Understanding Black-box Predictions via Influence Functions. Machine Learning with Adversaries: Byzantine Tolerant Gradient Descent. Comprehensive Privacy Analysis of Deep Learning: Passive and Active White-box. Inference Attacks against Centralized and Federated Learning. Towards Deep Learning Models Resistant to Adversarial Attacks. Certified Defenses against Adversarial Examples. An abstract domain for certifying neural networks. Adversarially Robust Generalization. Adversarial Examples Not as Bugs. Theoretically Principled Trade-off between Robustness and Accuracy. Industry Perspectives.	
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED
1. The research papers prescribed in the class.

Course Outcomes **At the end of the course, students will be able**	
CO1	to understand the taxonomy of the adversarial attacks.
CO2	to apply the adversarial use cases of machine learning applications.
CO3	to analyze the limitations of the conventional machine learning techniques in defending against the adversarial attacks.
CO4	to evaluate different security mechanism for adversarial machine learning.
CO5	to design the security mechanisms in a machine learning application to withstand the adversarial attacks.

M. Tech. – I (CSE) ISP Semester – II	**L**	**T**	**P**	**C**
CSIS128: MOBILE SECURITY AND PENETRATION TESTING (CORE ELECTIVE-3 OR 4)	**3**	**0**	**2**	**4**

Course Objective	
1	to understand the importance of security issues in mobile applications.
2	to enumerate the security vulnerabilities and exploits in the given applications on the android and the ios platforms.
3	to learn how the vulnerabilities are used to create an exploit for the applications on the android and the ios platforms.
4	to analyse software applications on the android and the ios platforms for the security issues therein.
5	to design the secure code and applications for the android and the ios platforms.
6	to apply the knowledge acquired to implement secure software for the android and the ios platforms.

BACKGROUND & INTRODUCTION	**(03 Hours)**
Introduction to the course. Review of the Mobile Application Security Landscape. The SmartPhone Market. The Android and iOS Operating Systems. Public Android and iOS Operating Systems Vulnerabilities. Key Challenges. Mobile Application Penetration Testing Methodology. The OWASP Mobile Security Project.	
THE ANDROID AND THE IOS ARCHITECTURES & TEST ENVIRONMENTS.	**(07 Hours)**
The Linux Kernel, the Android and the IOS architectures, the Java Virtual Machine, Core Java Libraries, The Application Layer and the application framework. The Android Application Components. The IOS Application Programming Languages, IOS Security Model. Hardware Level Security and Jailbreaking. The Mach-O binary file format. Mobile app penetration testing environment setup. The Android Studio and SDK. Genymotion. Configuring the emulator for http proxy. Google Nexus-5 physical device. SSH clients. Various tools in the IoS: Cydia, BigBoss, Darwins, iPA Installer, tcpdump, ios SSL Kill-switch. Emulators and simulators.	
MOBILE PENETRATION TOOLS	**(08 Hours)**
Android Security Tools: APKAnalyzer, The drozer tool, APKTool, the dex2jar API, JD-GUI, Androguard, Working with the Java debugger. iOS Security Tools: oTool, SSL Kill-switch, The Keychain dumper, LLDB, Clutch, Class-dump-z, Cycript, Frida, Hopper, Snoop-it.	
THREAT MODELLING A MOBILE APPLICATION	**(10 Hours)**
Basic concepts of threat modelling, Threats, Vulnerabilities, Risks. Approaches to Threat Model. Threat Agents in the mobile applications. How to create a threat model ? Using STRIDE, PASTA, Trike in Mobile Applications. Building Attack Plans, Threat Trees, Using Attack Patterns for Mobile Applications. Risk Assessment Models.	
ATTACKING ANDROID AND IOS APPLICATIONS	**(09 Hours)**
Attacking Android Applications: Setting up the target app. Analyzing apps using tools. Attacking activities, services, broadcast receivers, content providers, WebViews, SQL Injection, Man-in-the-middle attacks, SSL Spinning, Hardcoded credentials. Storage/archive analysis. Log analysis. Binary Patching. Attacking iOS applications: Setting up the target app. Storage/archive analysis. Reverse Engineering. Static code analysis. App patching, Runtime manipulation using. Cycript. Dumpdecrypted. Client-side injections. Man-in-the-middle attacks, SSL cert pinning. Building a remote tracer using LLDB	

SECURING ANDROID AND IOS APPLICATIONS.	**(08 Hours)**
Secure by design. Secure mind map for developers. Device level, platform level, application level protection. iOS cookie and keychains, App Storage protection. Application permissions.Securing Webview. Binary protection. Network level protection. OWASP mobile app security checklist. Secure coding Best practices for Android, iOS.	
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED

1. Vijay Kumar Velu, “Mobile Application Penetration Testing” , Packt Publishing Limited, 2016.
2. Jeff McWherter, Scott Gowell, “Professional Mobile Application Development”, Wrox Publications, 2012.
3. David Thiel ,“iOS Application Security: The Definitive Guide for Hackers and Developers”, No Starch Press, 2016.
4. David Rogers , “Mobile Security: A Guide for Users”, Lulu.com publishers 2013.
5. Kunal Relan , “ iOS Penetration Testing: A Definitive Guide to iOS Security”, Apres Publications, 2017.

Course Outcomes At the end of the course, students will	
CO1	The student will be able to identify the security issues in Android and iOS applications, using a wide variety of techniques including Reverse Engineering, Static/Dynamic/Runtime and Network Analysis.
CO2	The student will be able to code simple iOS and Android applications.
CO3	The student will be able to identify the vulnerabilities in the existing software, be able to decrypt and disassemble application
CO4	The student will be able to fully work exploits and malicious applications and thereby be able to learn the mitigation of the exploits.
CO5	The student will be able to design secure mobile applications.

M. Tech. – I (CSE) ISP Semester – II	L	T	P	C
CSIS130: SECURE SOFTWARE ENGINEERING (CORE ELECTIVE-3 OR 4)	3	0	2	4

Course Objective	
1	to understand the limitations of the security software and the motivation of designing secure software based on engineering principles.
2	to enumerate the security attacks at the various layers of the tcp/ip protocol suite as well as in the different phases of the sdlc.
3	to learn the common weaknesses in the memory unsafe and memory safe languages.
4	to analyse the code using static and dynamic analysis tools for security testing.
5	to design a secure model of the software using the attack trees, attack patterns and extensions to the uml for security.
6	to apply the principles learnt throughout the requirements analysis, specifications, design and implementation of the software.

INTRODUCTION	**(02 Hours)**
Introduction to the course. Review of Information Security concepts. The CIA Triad. Systems Security, Information Security, Application Security, Network Security – commonalities and differences. Essential Terminologies. Secure Software & its properties. Security Software: Critical shortcomings. Studies of various catastrophes due to Insecure software. What is Software Security? Software Assurance? Motivation for Software Security. Software Security vs Security Software. The trinity of troubles viz. Connectivity, Extensibility and Complexity. Model Based Security Engineering. Security in Software Development Lifecycle (SDLC). Software Security Best Practices applied to various software artifacts in the SDLC. Addressing security throughout the SDLC. Three Pillars of Software Security. Software Security Touchpoints.	
SECURITY ATTACKS AND TAXONOMY OF SECURITY ATTACKS	**(02 Hours)**
Review of security attacks – Taxonomy of Security Attacks, Methods. Attacks in each phase of the software life cycle. Attacks on the TCP/IP protocol suite layers. Motivation for attackers, Methods for attacks: Malicious code, Hidden software mechanisms, Social Engineering attacks, Physical attacks. Non-malicious dangers to software. The Denial of Service Attacks in each phase of the software life cycle. Security Vulnerabilities and Attack Taxonomy in Internet of Things and Cyber Physical Systems. Review of Malwares: Viruses, Trojans, and Worms. Malware Terminology: Rootkits, Trapdoors, Botnets, Keyloggers, Honeypots. IP Spoofing, Tear drop, DoS, DDoS attacks.	
THE SOFTWARE VULNERABILITIES	**(09 Hours)**
The Software Vulnerabilities: Vulnerabilities in the Memory-safe and memory-unsafe languages. Introduction to the Program Stack Analysis. Hands-on on Stack Analysis using gcc compiler and gdb debugger tool. Methods of security attack exploiting the vulnerabilities in the code. Taxonomy of security vulnerabilities. Remote Code Execution. State-of-the-art in research in Security Vulnerabilities. Overview of C, C++, Java Security Vulnerabilities.	
THE WEB VULNERABILITIES & COUNTERMEASURES	**(09 Hours)**
The common Web vulnerabilities: the Buffer Overflow - Stack overflows, Heap Overflows, the Code and Command Injections and the types: SQL injection, Cross-site scripting, Interpreter injection; the Format String vulnerabilities, writing shellcode. The Seven Pernicious Kingdoms. The Hidden form fields, Weak session cookies. Fault injection & Fault monitoring, Fail open authentication The OWASP Top 25 vulnerabilities in the current year.	
THE WEB VULNERABILITIES IN MEMORY SAFE LANGUAGES & COUNTERMEASURES	**(09 Hours)**

Introduction to Session Management in Web Applications. Session Management best practices. The XSRF (Cross-site Request Forgery) Attack. Security vulnerabilities in Java: Connection String Injection, LDAP Injection, Reflected XSS, Resource Injection, Persistent XSS attacks in Java, The XPath Injection. Insecure deserialization, Remote code execution (RCE). Log injection. Mail injection. Vulnerabilities in Java libraries. Vulnerabilities in the Java sandboxing mechanism. Insufficient Transport Layer Protection (ITLP). Application misconfiguration and Software Composition Analysis (SCA).	
CODE REVIEWS AND STATIC ANALYSIS OF THE SOURCE CODE	**(04 Hours)**
Introduction to Code reviews and Static Informal reviews, Formal inspections. Illustrations. Introduction to Code reviews and Static Analysis. Code Reviews. Static Code Analysis. Static and Dynamic Application Security Testing (SAST and DAST) tools. Using basic linting to detect security vulnerabilities in the code with the linux find(), grep(), awk(), splint() and the FlawFinder. A glance at Code Analyzer Tools : Top-10: Raxis, SonarQube for Code Quality and Code Security, PVS-Studio, reshift, Embold, SmartBear Collaborator, CodeScene Behavioral Code Analysis, RIPS Technologies. Others: Cscope, Ctags, Editors, Cbrowser. Comparison with the Dynamic Application Security Testing.	
THREAT MODELLING	**(06 Hours)**
Finding Threats: Using STRIDE, Attack Patterns, Attack Trees, Misuse Patterns. Threat modelling with Attack Trees and Graphs. Anti-models. State transition diagrams. Access control models. Specifying Secrecy, Authentication and Assertions. Graph based specifications, UML-based specifications. Formal Security specifications. Web Threats, Cloud Threats, Mobile Threats, Threats to Cyrptosystems. Attack Libraries: Properties, OWASP Top Ten, CAPEC. Threat Modeling tools: Secure Design – Principles: Secure Software Design Principles and Practices. Security Architectures. Design oriented, Goal oriented and Problem oriented approaches. Security Patterns: Modelling and Classification of Security Patterns. Patterns characterization. Security Design Approaches viz. UML, Secure UML, UMLSec and Misuse cases. Illustrating the design of a security protocol.	
SECURITY IN DESIGN	**(04 Hours)**
Secure Design – Principles: Secure Software Design Principles and Practices. Security Architectures. Design oriented, Goal oriented and Problem oriented approaches. Security Patterns: Modelling and Classification of Security Patterns. Patterns characterization. Security Design Approaches viz. UML, Secure UML, UMLSec and Misuse cases. Illustrating the design of a security protocol.	
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED
1. Andrew Magnusson, “Practical Vulnerability Management: A Strategic Approach to Managing Cyber Risks, No Starch Press,2020.
2. H Mouratidis, “ Software Engineering for Secure Systems – Industrial and Research Perspectives. Information Science Reference”, IGI global, 2011.
3. Gary McGraw, “Software Security : Building Security In”,Addison Wesley Software Security Series, 2006 edition.
4. Theodor Richardson, Charles Thies, “Secure Software Design”, Jones and Bartlet Learning, 2013
5. McDonald, Malcolm, “Web Security for Developers: Real Threats, Practical Defense”, United States, No Starch Press, 2020.

ADDITIONAL BOOKS RECOMMENDED
1. Palmer, Steven, “Web Application Vulnerabilities: Detect, Exploit, Prevent”, United States, Elsevier Science, 2011.

2. Tarandach, Izar, and Coles, Matthew J, “Threat Modeling”, India, O'Reilly Media, 2020.
3. Janca, Tanya, “Alice and Bob Learn Application Security”, United Kingdom, Wiley, 2020.

Course Outcomes **At the end of the course, students will**	
CO1	have a knowledge of the limitations of the security software and the need for the software security
CO2	be able to apply the concepts of software security learnt, to detect security vulnerabilities and prevent them.
CO3	be able to analyze the security issues in the Requirements, in the Specifications, in the Design and that in the software code.
CO4	be able to design the threat models and security mis-use case diagrams to model the security threats the software being developed.
CO5	be able to use the concepts of information security to prevent security design faults.

M. Tech. – I (CSE) ISP Semester – II	L	T	P	C
CSIS132: FOUNDATIONS OF PRIVACY ENGINEERING (CORE ELECTIVE-3 OR 4)	3	1	0	4

Course Objective	
1	to understand the privacy violations and the underlying causes.
2	to learn limitations of statistical disclosure.
3	to integrate privacy into the software engineering lifecycle phases
4	to collect, analyze and reconcile system requirements in a privacy-sensitive ecosystem
5	to evaluate software designs based on privacy principles and privacy requirements.

INTRODUCTION	**(09 Hours)**
Course Overview and Conceptual Privacy Frameworks. Fair Information Principles. Privacy in Context. Informational Privacy. The Constitutional Right to Privacy. Reductionism vs. Coherentism. Critiques of Privacy. Meaning and Value of Privacy. The Scope of Privacy. Privacy and Technology. Privacy as Contextual Integrity. A Taxonomy of Privacy. Privacy Technologies: Secret sharing and DC nets. The Dining Cryptographers Problem. Mix networks and onion routing. Untraceable Electronic Mail. Tor: The Second-Generation Onion Router. Anonymous communication. Oblivious Transfer and Garbled Circuits. How to Exchange Secrets with Oblivious Transfer. Yao's Garbled Circuits. Evaluating encrypted neural networks	
DATA USE ON THE WEB	**(06 Hours)**
Privacy and Contextual Integrity: Framework and Applications. Summary of the HIPAA Privacy Rule (Permitted Uses and Disclosures, Authorized Uses and Disclosures). A Formalization of HIPAA for a Medical Messaging System. Experiences in the Logical Specification of the HIPAA and GLBA Privacy Laws	
PRIVACY IN REQUIREMENTS	**(10 Hours)**
Requirements: Expressing, Analyze system and privacy requirements using natural language use cases and semi-formal models. Conflicts reconciliation between system requirements and privacy requirements. Sources of requirements, trace matrices to manage compliance. Legal or regulatory requirements, privacy principles, privacy patterns and privacy controls. Goal-based analysis to refine privacy goals into functional, privacy-enhancing system specifications. Privacy threat and risk analysis to apply different risk models to explore privacy threats, vulnerabilities and mitigations, including: a legal compliance model, a FIPs-based model, Calo's subjective/objective harms model, Solove's privacy harms taxonomy, and Nissenbaum's Contextual Integrity.	
PRIVACY IN DESIGN	**(10 Hours)**
Privacy by design. Alternative design strategies to implement requirements. Architecture vs. Policy - Boundary between engineering automation and human reliance. Translation of policy into system specifications. Data Lifecycle: collection, use, and retention to transfer. Designing for various privacy qualities, including collection and use limitation, data minimization, anonymization or de-identification, destruction, and individual participation, among others. Evolution & Adaptability affecting privacy, including deployment, maintenance and upgrades that risk privacy requirements violation.	
TESTING FOR PRIVACY	**(10 Hours)**
Testing and Validation. TESTING privacy requirements. Accommodating requirements that are not easily tested, privacy-protective activities. Code reviews and code audits, and auditing runtime behavior.	

Tutorial Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(15 Hours)**
(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

BOOKS RECOMMENDED

1. Axel van Lamsweerde, "Requirements Engineering: From System Goals to UML Models to Software Specifications" , John Wiley & Sons, Inc. 2009.
2. Vicenç Torra, "Data Privacy: Foundations, New Developments and the Big Data Challenge", Springer, 1st Edition, 2017.
3. The research papers prescribed in the class.
4. Stanford Encyclopedia of Philosophy: Article on Privacy, First Published, 2002. Substantive revision 2018.
5. Stallings, William, " Information Privacy Engineering and Privacy by Design: Understanding Privacy Threats, Technology, and Regulations Based on Standards and Best Practices", United Kingdom, Pearson Education, 2019.

Course Outcomes **At the end of the course, students will be able**	
CO1	To understand the privacy framework and principles
CO2	to integrate privacy into the software engineering lifecycle phases
CO3	to collect, analyze and reconcile system requirements in a privacy-sensitive ecosystem
CO4	to evaluate software designs based on privacy principles and privacy requirements
CO5	to interface with software developers on critical privacy issues

M. Tech. – I (CSE) ISP Semester – II	L	T	P	C
CSIS134: BITCOIN AND CRYPTOCURRENCY TECHNOLOGIES (CORE ELECTIVE-3 OR 4)	**3**	**0**	**2**	**4**

Course Objective	
1	to demonstrate a familiarity with the fundamentals of cryptocurrencies.
2	to understand different cryptographic primitives and their use in the design of cryptocurrencies.
3	to analyse different cryptocurrencies and to assess the pros and cons of different cryptocurrencies.
4	to design decentralized applications that operates using cryptocurrencies.
5	to propose and evaluate different use cases of cryptocurrencies.

FUNDAMENTALS OF BLOCKCHAIN TECHNOLOGY AND CRYPTOGRAPHY	**(09 Hours)**
Centralization vs. Decentralization, Distributed Consensus, Consensus Without Identity, Blockchain, Incentives and Proof of Work, Digital Signature, Tamper Proof Ledger, Distributed Consensus, Proof of Work, Mining and Currency Supply, Cryptographic Hash Functions, Hash Pointers and Data Structures, Digital Signatures, Public Keys as Identities	
BITCOIN - A CRYPTOCURRENCY	**(10 Hours)**
Bitcoin Transactions, Bitcoin Scripts, Applications of Bitcoin Scripts, Bitcoin Blocks, Bitcoin Network, Peer-to-Peer Network Architecture, Limitations & Improvements, Bitcoin Mining, Consensus, Decentralized Consensus, Mining Nodes, Bitcoin Addresses, Wallets, Alternative Chains, Bitcoin Security, Ways to Store and Use Bitcoins	
ETHEREUM	**(10 Hours)**
Ethereum and Turing Completeness, Wallet, Transactions, Metamask, Ether, Externally Owned Accounts (EOAs) and Contracts, Block Explorer, Ethereum Clients, Ethereum Networks, Smart Contracts and Solidity, Smart Contract Security, Ethereum Virtual Machine, Comparison of Bitcoin and Ethereum.	
OTHER CRYPTOCURRENCIES	**(09 Hours)**
Stellar: Stellar Network, Consensus Protocol, Ledger Format, Transactions, Smart Contracts, Monero: Cryptonote protocol, Transactions, Mining, Ring Signatures, Zcash: Zero Knowledge Proofs, Mining, Comparison between Bitcoin, Ethereum, Monero, Zcash, and Other Cryptocurrencies.	
FINTECH AND APPLICATIONS	**(07 Hours)**
Hot and Cold Storage, Splitting and Sharing Keys, Online Wallets and Exchanges, Payment Services, Transaction Fees, Currency Exchange Markets, Building the Blockchain, Crypto Finance, Business Use Cases, Blockchain in Gaming, Investing in Blockchain, Government and Regulation, FinTech.	
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED

1. Andreas M. Antonopoulos, “Mastering Bitcoin: Programming the Open Blockchain”, Shroff/O'Reilly, 2017.
2. Antonopoulos, Andreas M. and Wood, Gavin, “Mastering Ethereum”, O’Reilly Media, Inc., 2018.
3. Arvind Narayanan, Joseph Bonneau, Edward Felten, andrew Miller, Steven Goldfeder, “Bitcoin and Cryptocurrency Technologies: A Comprehensive introduction”, Princeton University Press,

2016.
4. Franco, Pedro, “ Understanding Bitcoin: Cryptography, engineering and economics”, John Wiley & Sons, 2014.
5. Elrom, Elad, “The blockchain developer: A Practical Guide for Designing, Implementing, Publishing, Testing, and Securing Distributed Blockchain-based Projects” , Apress, 2019.

ADDITIONAL BOOKS RECOMMENDED

1. Roger Wattenhofer, “Blockchain Science: Distributed Ledger Technology”, independently Published, ISBN-10 : 1793471738, 2019.

Course Outcomes At the end of the course, students will	
CO1	have knowledge about the design principles of blockchain and cryptocurrencies.
CO2	be able to program and demonstrate the working of different consensus mechanisms.
CO3	be able to analyse Cryptocurrency transactions, scripts, and network.
CO4	be able to design decentralized applications that relies on cryptocurrencies.
CO5	be able to analyse the strengths and weaknesses of various cryptocurrencies.

M. Tech. – I (CSE) ISP Semester – II	L	T	P	C
CSIS136: ADVANCED CRYPTOGRAPHY (CORE ELECTIVE-3 OR 4)	**3**	**0**	**2**	**4**

Course Objective	
1	to demonstrate a familiarity with concepts related to number theory and apply them in modern cryptography.
2	to analyse the design of the state-of-the-art cryptosystems and assess their strengths and weaknesses.
3	to apply the knowledge of cryptography to solve real-world problems in the area of multi-party computation, secure storage at third party servers, etc.
4	to understand and analyze the design of advanced cryptosystems related to lattice-based cryptography, homomorphic encryption, and attribute-based encryption.

INTRODUCTION	**(05 Hours)**
One-way Functions (OWFs), Pseudorandom Generators (PRGs), Pseudorandom Functions (PRFs), Pseudorandom Permutations (PRSs), The Blum-Micali PRG and hybrid arguments, The Goldreich-Goldwasser-Micali PRF construction.	
SYMMETRIC CRYPTOGRAPHY	**(05 Hours)**
Symmetric Cryptography, Symmetric Encryption: Semantic Security, CPA-Security, Message Integrity and Message Authentication Codes (MACs), Authenticated Encryption, Differential Cryptanalysis, Linear Cryptanalysis.	
NUMBER-THEORETIC CRYPTOGRAPHY	**(06 Hours)**
The Discrete Logarithm Problem, Diffie-Hellman Key Exchange and ElGamal Encryption, Random Self-Reducibility and The Naor-Reingold PRF, Factoring and The RSA Assumption, Trapdoor Permutations and Digital Signatures, The Random Oracle Model.	
ELLIPTIC-CURVE CRYPTOGRAPHY	**(07 Hours)**
Generic Algorithms for Discrete Logarithm, Elliptic-Curve Cryptography: Notation, Definitions, and Constructions, Introduction to Pairing-Based Cryptography, 3-Party Non-Interactive Key-Exchange from Pairings, Short Signatures From Pairings, Identity-Based Encryption from Pairings.	
ENCRYPTED DATA PROCESSING	**(06 Hours)**
Homomorphic Signatures, Partial Homomorphic Encryption, Somewhat Homomorphic Encryption, Fully Homomorphic Encryption, Dual Regev Encryption, Attribute-Based Encryption.	
ZERO-KNOWLEDGE PROOF	**(06 Hours)**
Zero-Knowledge Proof System, Interactive Proof Systems, Zero-Knowledge Proof Systems and The Simulation Paradigm, Zero-Knowledge Proofs for NP, Proofs of Knowledge, Sigma Protocols: Schnorr Signatures and Chaum-Pedersen Proofs, The Fiat-Shamir Heuristic, Differential Privacy.	
MULTI-PARTY COMPUTATION SYSTEMS	**(04 Hours)**
Secure Multi-Party Computation, Oblivious Transfer Protocols, Yao's Garbled Circuits, Shamir Secret Sharing, Computing on Secret-Shared Data, SMPC in the Preprocessing Model: OT Correlations and Beaver Triples.	
LATTICE-BASED CRYPTOGRAPHY	**(06 Hours)**
Overview of Post-Quantum Cryptography, Introduction to Lattice-Based Cryptography, The Short Integer Solutions (SIS) Problem, Lattice Trapdoors, and Lattice-Based Signatures, The Learning With Errors (LWE) Problem, Regev's Public-Key Encryption Scheme from LWE.	
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**

(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

BOOKS RECOMMENDED

1. Boneh, Dan, and Victor Shoup. "A graduate course in applied cryptography." Recuperado de https://crypto. stanford. edu/~ dabo/cryptobook/BonehShoup_0_4. pdf (2017).
2. Katz, Jonathan, and Yehuda Lindell. "Introduction to modern cryptography.", CRC press, (2020).
3. Goldreich, Oded. "Foundations of cryptography: volume 1 basic tools", Cambridge University Press, (2009).
4. Goldreich, Oded. "Foundations of cryptography: volume 2 basic applications", Cambridge University Press, (2009).
5. Bellare, Mihir, and Phillip Rogaway. "Introduction to modern cryptography." ,UCSD CSE 207 (2005).

Course Outcomes
At the end of the course, students will

CO1	be able to define advanced cryptography terminologies.
CO2	be able to apply various security models while designing applications and different security mechanisms to provide different security services that protect against security attacks.
CO3	be able to analyze different security models and protocols.
CO4	be able to evaluate encrypted data using encrypted data processing techniques.
CO5	be able to design, build, and deploy secure applications.

M. Tech. – I (CSE) ISP Semester – II	L	T	P	C
CSIS138: SECURITY PROTOCOLS (CORE ELECTIVE-3 OR 4)	**3**	**0**	**2**	**4**

Course Objective	
1	to understand concepts of security protocols and its analysis.
2	to understand how applications can communicate securely and what tools and protocols exist in order to offer different levels of security.
3	to get knowledge and the ability to critically analyze and design secure networks, applications and systems.
4	to give hands-on experience in using automated tools and formal techniques to analyze and evaluate cryptographic protocols and other security mechanisms.
5	to analyze various existing protocols in terms of the goals.

INTRODUCTION TO SECURITY PROTOCOLS	**(04 Hours)**
Introduction to Computer Security, Security Protocols, Security Analysis	
TRANSPORT LAYER SECURITY	**(05 Hours)**
Overview of SSL/TLS, Creating An Abstract Model, Coding Up in Murphi, Specification and Verification of Security Properties.	
KEY EXCHANGE PROTOCOLS	**(04 Hours)**
Key Management, Kerberos, Public-Key infrastructure, Security Properties and Attacks on Them, Needham-Schroeder Lowe Protocol, Diffie-Hellman Key Exchange, IPSec, Ike.	
CONTRACT-SIGNING PROTOCOLS	**(05 Hours)**
Fundamental Limitation of Contract-Signing and Fair-Exchange, Trusted Third Party, Optimistic Contract-Signing, Asokan-Shoup-Waidner Protocol, Desirable Properties (Fairness, Timeliness, Accountability, Balance), Abuse-Free Contract-Signing.	
PASSWORD AUTHENTICATION	**(04 Hours)**
Hashed Password Files and Salt, Web Authentication Issues: Sniffing, Phishing, Spyware, Password-Authenticated Key Exchange Protocols.	
PROBABILISTIC MODEL CHECKING	**(05 Hours)**
Crowds System, Probabilistic Notions of Anonymity, Markov Chains, Prism, PCTL Logic, Probabilistic Fair Exchange.	
PROTOCOL VERIFICATION BY THE INDUCTIVE METHOD	**(04 Hours)**
Protocol Analysis Using Theorem Proving, Inductive Proofs, Isabelle Theorem Prover, Verifying the Secure Electronic Transactions (Set) Protocols Using Isabelle.	
PROBABILISTIC CONTRACT SIGNING	**(04 Hours)**
Rabin's Beacon, Rabin's Contract Signing Protocol, BGMR Probabilistic Contract Signing, formal Model for the BGMR Protocol.	
GAME-BASED VERIFICATION OF FAIR EXCHANGE PROTOCOLS	**(04 Hours)**
The Problem of Fair Exchange, Protocol As A Game Tree, Alternating Transition Systems, Alternating-Time Temporal Logic, Mocha Model Checker.	
OTHER SECURITY PROTOCOLS	**(06 Hours)**
Yahalom Protocol: Secrecy, Authentication, Non-Repudiation, Anonymity; Dolev-Yao Threat Model, Needham- Schroeder Public-Key Protocol and Its Security Analysis. Wireless Networking Protocol, Logic for Computer Security Protocols: Floyd-Hoare Logic of Programs, Ban Logic, Compositional Logic for Proving Security Properties of Protocols, Probabilistic Polynomial-Time Process Calculus for	

Security Protocol Analysis.	
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED

1. Peter Ryan, Steve Schneider, Michael Goldsmith, Gavin Lowe, Bill Roscoe, " Modelling & Analysis of Security Protocols", Addison Wesley, 2000.
2. Stephen W. Mancini, "Automating Security Protocol Analysis", Biblioscholar, 2012.
3. Ulysess Black, "Internet Security Protocols: Protecting IP Traffic", Prentice Hall PTR; 1st edition, ISBN-10: 0130142492, ISBN-13: 978-0130142498, 2000.
4. Giampaolo Bella, "formal Correctness of Security Protocols", Springer, 2007.
5. Dinesh Goyal, S. Balamurugan, Sheng-Lung Peng, O.P. Verma, "Design and Analysis of Security Protocol for Communication, Scrivener Publishing, 2020.

Course Outcomes
At the end of the course, students will

CO1	be able to understand different authentication techniques, key exchange protocols and security issues while designing the protocols.
CO2	be able to get a hands-on exposure to the principles and techniques used in security systems, as well as designing security protocols.
CO3	be able to analyse the security protocols against different attacks.
CO4	be able to evaluate vulnerabilities in the security systems
CO5	be able to design a key agreement or key transport or key establishment protocol satisfying various security goals.

M. Tech. – I (CSE) ISP Semester – II	**L**	**T**	**P**	**C**
CSIS140: HARDWARE SECURITY (CORE ELECTIVE-3 OR 4)	**3**	**0**	**2**	**4**

Course Objective	
1	to understand hardware based security primitives and protocols
2	to identify security threats for modern hardware design and practices
3	to understand different defense techniques to secure hardware
4	to explore practical real world case studies to design secure hardware

INTRODUCTION TO HARDWARE SECURITY	**(04 Hours)**
Overview and Layers of Computing System, Hardware Trust and Security, Attacks, Vulnerabilities, and Countermeasures, Conflict Between Security and Test/Debug	
HARDWARE TROJANS	**(07 Hours)**
Introduction, SoC Design Flow, Hardware Trojans, Hardware Trojans in FPGA Designs, Hardware Trojans Taxonomy, Trust Benchmarks, Countermeasures Against Hardware Trojans, Hands-on Experiment: Hardware Trojan Attacks	
HARDWARE IP PIRACY AND REVERSE ENGINEERING	**(07 Hours)**
Introduction, Hardware intellectual Property (IP), Security Issues in IP-Based SoC Design- Hardware Trojan Attacks, IP Piracy and Overproduction, Reverse Engineering, Security Issues in FPGA- FPGA Preliminaries, Lifecycle of FPGA-Based System, Hands-on Experiment: Reverse Engineering and Tampering	
SIDE-CHANNEL ATTACKS	**(08 Hours)**
Taxonomy of Side-Channel Attacks, Power Analysis Attacks-, Higher-order Side-Channel Attacks, Electromagnetic (EM) Side-Channel Attacks, Fault injection Attacks, Timing Attacks, Covert Channels.	
PCB SECURITY	**(08 Hours)**
PCB Security Challenges, Attacks on PCB, PCB Authentication, Sources of PCB Signature, Signature Assessment Metric, PCB integrity Validation.	
HARDWARE SECURITY PRIMITIVES	**(07 Hours)**
Physically Unclonable Function, True Random Number Generator, Design for Anti-Counterfeit, Hardware Obfuscation, Use of Obfuscation Against Trojan Attacks	
ADVANCED TOPICS	**(04 Hours)**
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

BOOKS RECOMMENDED

1. Ahmad-Reza Sadeghi, David Naccache, “ Towards Hardware-intrinsic Security”, Springer, 2010.
2. Debdeep Mukhopadhyay and Rajat Subhra Chakraborty, “ Hardware Security: Design, Threats, and Safeguards”, CRC Press.
3. Stefan Mangard, Elisabeth Oswald, Thomas Popp, “Power analysis attacks - revealing the secrets of smart cards”, Springer 2007.
4. Rebeiro Chester, Mukhopadhyay Debdeep, Bhattacharya Sarani, “ Timing Channels in Cryptography A Micro-Architectural Perspective”, Springer. 2015.
5. Ted Huffmire et al, “Handbook of FPGA Design Security” , Springer. 2014.

Course Outcomes At the end of the course, students will	
CO1	be able to understand hardware security concepts
CO2	be able to assess the security of different hardware designs
CO3	be able to apply different hardware security techniques for modern hardware designs
CO4	be able to implement and evaluate different hardware security techniques.
CO5	be able to design secure hardware systems

M. Tech. – I (CSE) ISP Semester – I	**L**	**T**	**P**	**C**
CSIS172: SOCIAL NETWORKS (INSTITUTE ELECTIVE)	**3**	**0**	**0**	**3**

Course Objective	
1	To understand the social network models, representation and analytics.
2	To identify the unique challenges involved in social network research.
3	To apply techniques for social network representation and analytics for real-word scenarios.
4	To analyse and evaluate the social network research solutions for real-world scenarios.

INTRODUCTION	**(09 Hours)**
Introduction To Social Networks: Networks as Information Maps, Networks as Conduits, Connections, Propinquity, Homophily	
SOCIAL NETWORK REPRESENTATION	**(18 Hours)**
Social Network Analysis:Mathematical Foundations, Data Collection, Data Management, Visualization, Centrality, Subgroups, Cliques, Clusters, Dyads and Triads, Density, Structural Holes, Weak Ties, Centrality, The Small World, Circles, and Communities, Multiplicity, Structural Similarity and Structural Equivalence	
SOCIAL NETWORK ANALYSIS	**(09 Hours)**
Social Networks and Diffusion: Influence and Decision-Making, Epidemiology and Network Diffusion, Tipping Points and Thresholds	
TOOLS AND CASE STUDIES	**(09 Hours)**
Social Network Tools and Case Studies	
	(Total Contact Time: 45 Hours)

BOOKS RECOMMENDED

1. Borgatti SP, Everett MG, Johnson JC, “Analyzing Social Networks”, London, Sage Publication, 2013.
2. Kadushin C., “Understanding Social Networks: Theories, Concepts and Findings”, Oxford University Press, 2012.
3. Piet A.M. Kommers, Pedro Isaias, Tomayess Issa, “Perspectives on Social Media: A Yearbook”, Taylor and Francis, 2014.
4. Newman Mark, “Networks: An Introduction”, Oxford university press, 2018.
5. Brath Richard, David Jonker, "Graph analysis and visualization: Discovering Business Opportunity in Linked Data", John Wiley & Sons, 2015.

Course Outcomes At the end of the course, students will	
CO1	have the knowledge of various social network representation, visualization and analytics tools and techniques.
CO2	be able to apply tools for social network data acquisition, management and analytics.
CO3	be able to analyse and evaluate the social network research solutions for real-world scenarios
CO4	be able to design the social network analytics solution for the complex real-world problem.

M. Tech. – I (CSE) ISP Semester – II	L	T	P	C
CSIS174: CYBER LAWS (INSTITUTE ELECTIVE)	**3**	**0**	**0**	**4**

Course Objective	
1	The course aims at acquainting the students with the basic concepts of Cyber Law and also puts those concepts in their practical perspective.
2	It also provides an elementary understanding of the authorities under IT Act as well as penalties and offences under IT Act.
3	It also covers overview of Intellectual Property Right and Trademark Related laws with respect to Cyber Space.
4	Student will get the knowledge about the E- Governance policies of India.

INTRODUCTION OF CYBER CRIMES & CYBER LAW	**(07 Hours)**
Understanding Cyber Crimes and Cyber Offences, Crime in context of Internet, Types of Crime in Internet, Crimes targeting Computers: Definition of Cyber Crime & Computer related Crimes, Constraint and Scope of Cyber Laws, Social Media and its Role in Cyber World, Fake News, Defamation, Online Advertising.	
PREVENTION OF CYBER CRIMES & IT ACT 2000	**(07 Hours)**
Prevention of Cyber Crimes & Frauds, Evolution of the IT Act 2000, Genesis and Necessity. Critical analysis & loopholes of The IT Act, 2000 in terms of cyber-crimes, Cyber Crimes: Freedom of speech in cyber space & human right issues.	
FEATURES OF IT ACT 2000 & AMENDMENTS	**(07 Hours)**
Salient features of the IT Act, 2000, Cyber Tribunal & Appellate Tribunal and other authorities under IT Act and their powers, Penalties & Offences under IT Act, Amendments under IT Act and Impact on other related Acts (Amendments): (a) Amendments to Indian Penal Code. (b) Amendments to Indian Evidence Act. (c) Amendments to Bankers Book Evidence Act. (d) Amendments to Reserve Bank of India Act.	
INDIAN PENAL LAW	**(06 Hours)**
Indian Penal Law and Cyber Crimes: (i) Fraud, (ii) Hacking, (iii) Mischief, Trespass (iv) Defamation (v) Stalking (vi) Spam, Issues of Internet Governance: (i) Freedom of Expression in Internet (ii) Issues of Censorship (iii) Hate Speech (iv) Sedition (v) Libel (vi) Subversion (vii) Privacy, Cyber Appellate Tribunal with Special Reference to the Cyber Regulation Appellate Tribunal (Procedures) Rules 2000.	
GLOBAL IT RULES & IPR	**(06 Hours)**
The Information Technology (Procedures and Safeguards for Interception, Monitoring and Decryption of Information) Rules, 2009 and Corresponding International Legislation in US, UK and Europe, The Information Technology (Procedures and Safeguards for Blocking the access of Information by Public) Rules, 2009 and Corresponding International Legislation in US, UK and Europe, The Information Technology (Reasonable Security Practices and Procedures and Sensitive Personal Data or Information) Rules, 2009 and Corresponding International Legislation in US, UK and Europe, Intellectual Property Right (IPR).	
CYBER SPACE & E-GOVERNANCE IN INDIA	**(06 Hours)**
Cyber and Cyber Space with reference to Democracy and Sovereignty, Developments in Cyber law Jurisprudence, Role of law in Cyber World: Regulation of Cyber Space in India, Role of RBI and Legal Issues in case of e-commerce, E-Governance in India: Law, Policy, Practice.	
CYBERSPACE JURISDICTION	**(06 Hours)**
Cyberspace Jurisdiction (a) Jurisdiction issues under IT Act, 2000. (b) Traditional principals of Jurisdiction	

(c) Extra-terrestrial Jurisdiction (d) Case Laws on Cyber Space Jurisdiction (e) Taxation issues in Cyberspace.	
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

BOOKS RECOMMENDED

1. Vakul Sharma , "Information Technology Law and Practice- Cyber Laws and Laws Relating to E-Commerce", Universal Law Publishing - An imprint of LexisNexis.
2. Duggal Pavan , "Legal Framework on Electronic Commerce and Intellectual Property Rights in Cyberspace", Universal Law Publishing - An imprint of LexisNexis.
3. Yatindra Singh , "Cyber Laws: A Guide to Cyber Laws, Information Technology, Computer Software, Intellectual Property Rights, E-commerce, Taxation, Privacy, Etc. Along with Policies, Guidelines and Agreements", Universal Law Publishing
4. Santosh Kumar, "Cyber Laws & Cyber Crimes", WHITESMANN.
5. Akash Kamal Mishra , "Cyber Laws in India - Fathoming Your Lawful Perplex " , Notion Press, 2020.

Course Outcomes At the end of the course, students will be able	
CO1	Students will be able to understand the types of Crime in Internet, Crimes targeting Computers and Scope of Cyber Laws.
CO2	Students will be able to apply the cyber laws to relate the various evidences of cybercrimes.
CO3	Students will be able to analyze the various evidence of cybercrimes to be allied with the particular cyber law.
CO4	Students will be able to evaluate the particular intellectual property rights according to the cyber law.
CO5	Students will be able to design an application to counter the cybercrimes.

M. Tech. – I (CSE) ISP Semester – II	**L**	**T**	**P**	**C**
CSIS176: ETHICAL HACKING AND PENETRATION TESTING (INSTITUTE ELECTIVE)	**3**	**0**	**2**	**4**

Course Objective	
1	to describe the fundamental concepts of protecting a network from attacks.
2	to enumerate the techniques for collecting the network and the host information by a remote user.
3	to learn the techniques by which the adversary can discover and do mapping of systems, can orchestrate unauthorized manipulation of data, disable network systems or services and deny access to resources by legitimate users.
4	to analyse the techniques used by the adversary to detect the common vulnerabilities.
5	to apply the knowledge gained to protect the network as well as the host systems from the adversary attacks.

INTRODUCTION	**(04 Hours)**
Review of the Network Fundamentals, Network Topologies, Network Components, TCP/IP Networking Basics, TCP/IP Protocol Stack: DNS, SNMP, TCP, UDP, IP, ARP, RARP, ICMP protocols. Ethernet, Subnet Masking, Subnetting, Supernetting. Review of the Security Basics: Attributes, Mechanisms and Attacks Taxonomy. The CIA Traid. Threats, Vulnerabilities, Attacks	
NETWORK SECURITY CONCERNS	**(04 Hours)**
Network Security Concerns. Fundamental Network Security Threats. Types of Network Security Threats. Network Security Vulnerabilities, their types: Technological Vulnerabilities, Configuration Vulnerabilities, Security policy Vulnerabilities. Types of Network Security Attacks	
INTELLIGENCE (INT) GATHERING	**(09 Hours)**
Learning about the target, its business, its organizational structure, and its business partners. To output the list of company names, partner organization names, and DNS names, and the servers. The concepts of Search engines, Financial databases, Business reports. The use of WHOIS, RWHOIS, Domain name registries and registrars, Web archives and the corresponding open source tools for mining these data. Cloud reconnaissance.	
NETWORK FOOTPRINTING	**(09 Hours)**
Active & Passive Footprinting. Network and system footprinting. Tools for network footprinting. Using Search engines to find the tools. Mining the DNS host names, corresponding IP addresses, IP address ranges, Firewalls, Network maps. Use of search engines, social media, social engineering, the websites of the target organization. Using archive.org. Using Neo trace, *DNS Footprinting* and whois databases. Use of the contemporary tools (e.g. png, port scanners) for finding these information. Email footprinting. Email Tracking. Footprinting through Google tools. Using traceroute. Verification to confirm the validity of information collected in the prior phases. The countermeasures to prevent successful network footprinting.	
SCANNING & ENUMERATION	**(09 Hours)**
Scanning: goals and type, overall scanning tips, sniffing with tcpdump, network tracing, port scanning. OS fingerprinting, version scanning. Identify open ports. Web Service Review Tools: Identify web-based vulnerabilities. Network Vulnerability Scanning Tools: Identify infrastructure-related security issues. The illustrative tools are Nmap, ping, AngryIP, Nikto, OpenVAS, udp-proto-scanner, Netsparker, Nessus, Masscan, SQLMap, Nexpose, Burpsuite, Qualys, HCL AppScan, Amass, wpscan, Eyewitness, WebInspect, ZAP. Stealth Scanning: Scanning Beyond an IDS. Network diagram generation using typical tools viz. Network Topology Mapper, OpManager, LANState, Friendly	

Pinger. Proxy Servers, The Onion Routing. http tunneling. ssh tunneling. Anonymizers.	
EXPLOITATION	**(10 Hours)**
Network based exploitation: using tools such as Metasploit to compromise vulnerable systems, basics of pivoting, and pilfering. Detection of IP Spoofing. Common web vulnerabilities: Cross-site scripting, OS and Command injections, Buffer overflows, SQL injection, race conditions, and such other vulnerabilities scanning and exploitation techniques, including those in OWASP Top 25. Extracting information about the user names using email IDs, the list of default passwords used by the products used at the target, usernames using the SNMP protocol, user groups from Windows and the DNS zone transfer information. SuperScan. Route Analysis Tools. SNMP Enumeration. Reconnaissance Attacks and how to mitigate reconnaissance attacks.	
Practical Assignments Will Be Based on the Coverage of Above topics. (Problem Statements will be changed every year and will be notified on Website.)	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

BOOKS RECOMMENDED

1. John Slavio, "Hacking: A Beginners' Guide to Computer Hacking, Basic Security, And Penetration Testing".
2. Yuri Diogenes, Dr. Erdal Ozkaya, "Cybersecurity – Attack and Defense Strategies: Counter modern threats and employ state-of-the-art tools and techniques to protect your organization against cybercriminals", 2nd Edition Kindle Edition, Packt Publishing; 2nd edition, 2019.
3. Hidaia Mahmood Alassouli, "Footprinting, Reconnaissance, Scanning and Enumeration Techniques of Computer Networks", Blurb Publishers.
4. Robert Shimonski, "Cyber Reconnaissance, Surveillance and Defense 1st Edition, Kindle Edition, Syngress; 2014.
5. Sikorski, Michael, and Honig, Andrew, "Practical Malware Analysis: The Hands-On Guide to Dissecting Malicious Software", United States, No Starch Press, 2012.

ADDITIONAL BOOKS RECOMMENDED

1. Dafydd Stuttard and Marcus Pinto, "The Web Application Hacker's Handbook: Finding and Exploiting Security Flaws".

Course Outcomes
At the end of the course, students will

CO1	have a knowledge of the basic concepts of network, host, services and vulnerability gathering techniques employed by an attacker.
CO2	be able to use the tools for doing network footprinting including stealth scanning.
CO3	be able to analyze the installations for the vulnerabilities that could be exploited by an adversary.
CO4	be able to design secure system installations that can withstand adversarial attacks.
CO5	be able to extend the existing tools for network and systems protection.

ANNEXURE- I

Post Graduate Programme

M. Tech.

in

Power Electronics & Electrical Drives

Proposed Curriculum

(as per NEP)

सरदार वल्लभभाई राष्ट्रीय प्रोद्योगिकी संस्थान, सूरत
SARDAR VALLBHBHAI NATIONAL INSTITUTE OF TECHNOLOGY, SURAT
विधुत इंजीनियरिंग विभाग
DEPARTMENT OF ELECTRICAL ENGINEERING

<u>**Teaching Scheme of M. Tech. (Power Electronics and Electrical Drives)**</u>

Sr. No.	Subject	Code	Scheme L-T-P	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
				Th.	T	P		
				Marks		Marks		
	First Semester							
1	Power Electronics- I	EEPE101	3-1-2	100	25	50	05	100
2	Modelling of Electrical Machines and DC Drives	EEPE103	3-1-2	100	25	50	05	100
3	Solar and Wind Energy Conversion and Control	EEPE105	3-0-2	100	00	50	04	85
4	Elective -1	EEPE1XX	3-0-0	100	-	-	03	55
5	Elective -2	EEPE1XX	3-0-0	100	-	-	03	55
						Total	**20**	**395**
7	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	EEPE91 EEPE93	0-0-10				5	200 (20 x 10)
	Second Semester							
1	Power Electronics- II	EEPE102	3-1-2	100	25	50	05	100
2	AC Drives	EEPE104	3-1-2	100	25	50	05	100
3	Elective -3	EEPE1XX	3-0-0	100	-	-	03	55
4	Elective -4	EEPE1XX	3-0-0	100	-	-	03	55
5	Institute Elective**- I***	EEPE1XX	3-0-0	100	-	-	03	55
6	Mini Project	EEPE106	0-0-4	00	00	50	02	70
						Total	**21**	**435**
7	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	EEPE92 EEPE94	0-0-10				5	200 (20 x 10)
	Third Semester							
1	MOOC course- I* (Swayam/NPTEL)	Φ-	3/4-0-0	100	00	00	3/4	70/80
2	MOOC course- II* (Swayam/NPTEL)	Φ-	3/4-0-0	100	00	00	3/4	70/80
3	Dissertation Preliminaries	EEPE295	0-0-28	-	-	350$	14	560
						Total	**20-22**	**700-720**
	Fourth Semester							
1	Dissertation	EEPE296	0-0-40	-	-	600$	20	800
						Total	**20**	**800**

L: Lecture; T: Tutorial; P: Practical; Th: Theory

$ **Internal**: 40% and **External**: 60%

*Swayam/NPTEL

Φ As per 66th IAAC, Dated 20th March, 2024, Resolution No. 66.34 and 61st Senate resolution No. 4, 25th April, 2024

*****to be offered to the PG students of other department and other PG Programs with the department

List of Elective Courses Offered

Elective – 1 (EEPE1XX)		
S. No.	Code	Subject
(1)	EEPE111	Power Quality Disturbance and its Mitigation
(2)	EEPE113	High Power Converter Topologies and Control
(3)	EEPE115	Digital Signal Processing
(4)	EEPE117	Microcontroller-Based System Design
(5)	EEPE119	Physical Phenomena of Electrical Machines
Elective – 2 (EEPE1XX)		
S. No.	Code	Subject
(1)	EEPE131	Advanced Numerical Methods and Applications
(2)	EEPE133	System Theory
(3)	EEPE135	Control Techniques in Switch-Mode Power Converters
(4)	EEPE137	Design of Magnetic Components for Power Converters
(5)	EEPE139	Electric Vehicle Technology
(6)	EEPE141	Adaptive Control and Soft Computing
Elective – 3 (EEPE1XX)		
S. No.	Code	Subject
(1)	EEPE112	Charging Infrastructure for Electric Vehicles
(2)	EEPE114	Special Electrical Machines and Drives
(3)	EEPE116	Advance Power Converters for Renewable Applications
(4)	EEPE118	Distributed Power Generation and Micro-grid
(5)	EEPE120	HVDC Transmission
(6)	EEPE122	Condition Monitoring & Fault Diagnosis Of Electrical Machines
(7)	EEPE124	Digital Control of Power Converters
Elective – 4 (EEPE1XX)		
S. No.	Code	Subject
(1)	EEPE132	Advanced Energy Storage Devices and Applications
(2)	EEPE134	Instrumentation for Drives
(3)	EEPE136	Application of Power Electronics to Power System
(4)	EEPE138	Model Predictive Control for Power Electronics Applications
(5)	EEPE140	Electrical Machines For Renewable Energy Generation
(6)	EEPE142	FPGA based Control of Power Electronic Converters
Institute Elective – 1 (EEPE1XX)		
S. No.	Code	Subject
(1)	EEPE172	Artificial Intelligence and Machine Learning
(2)	EEPE174	Modern Industrial Drives and Automation
(3)	EEPE176	Advanced Optimization Methods
(4)	EEPE178	Smart Grid Technology

M. Tech. (Electrical), Semester – I

EEPE101: POWER ELECTRONICS – I

L	T	P	C
3	1	2	5

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	classify the power semi-conductor devices, select the devices suitable to the application
CO2	analyze DC-DC converters, Inverters and Line Commutated Converters
CO3	learn different control techniques for Inverters
CO4	model the converter and design the controller
CO5	learn advanced converters

2. SYLLABUS

- **REVIEW OF POWER SEMICONDUCTOR DEVICES** **(05 Hours)**

  Static and Switching Characteristics of Power semiconductor devices, Device Loss Calculation, Applications.

- **LINE COMMUTATED CONVERTERS** **(10 Hours)**

  Principle of phase control, Review of single phase and three-phase converters, Multi-pulse converters, Three-phase AC voltage controllers

- **DC-DC CONVERTERS** **(12 Hours)**

  Buck converter, Boost converter, Buck–Boost converters, CUK converter, Fly-back converter, Forward converter, Push–pull converter, Full bridge and Half bridge converters, SEPIC Converter, Power Circuit Design considerations, Small Signal Modeling of DC-DC Converters, Closed loop control, Controller Design.

- **PWM INVERTERS** **(18 Hours)**

  Voltage Source Inverter Topologies: Single phase, 3-phase bridge inverter with R, RL, RLE load, Current source inverters, Applications, **Modulation Techniques:** single-pulse and multi pulse modulation, Selective Harmonic Elimination Technique, Delta modulation, Sinusoidal PWM, Space Vector PWM, Comparison of PWM techniques

Total Hours: 45

Note: Tutorials will be conducted separately for 15 hours

3. LIST OF EXPERIMENTS

1. Study of MOSFET IGBT Characteristics.
2. Study of single-phase controlled rectifiers with R and R-L load.
3. Study of single-phase AC voltage controller using SCR as well as using TRIAC with R and R-L load.
4. Study of single-phase SCR full bridge inverter circuit.
5. Study of three-phase SPWM inverter.
6. Study of three-phase fully controlled rectifier with R and R-L load.
7. Study of three-phase AC voltage Regulator.
8. Study of single-phase IGBT based full bridge inverter circuit.
9. Simulation of DC - DC Converter: (i) Buck Converter; (ii) Boost Converter; and (iii) Buck-Book Converter.
10. Simulation of single phase controlled rectifier different configurations with R, R-L, R-L-E load.
11. Simulation of three phase controlled rectifier different configurations with R, R-L, R-L-E load.
12. Simulation of single phase AC voltage controlled rectifier different configurations.
13. Simulation of three phase AC voltage controlled rectifier different configurations.
14. Simulation of single phase inverter: (i) Square wave; (ii) Quasi square wave; (iii) Selective harmonic elimination and (iv) sine PWM.
15. Simulation of three phase inverter: (i) 120^0; (ii) 180^0 mode; (iii) Selective harmonic elimination and (iv) sine PWM.

4. BOOKS RECOMMENDED:

1. Rashid, M. H., "Power Electronics Circuits, Devices, and Applications, Prentice-Hall of India Pvt. Ltd., New Delhi, 2nd edition, 1999.
2. Ned Mohan, Tore M. Undeland and William P. Robbins, “Power Electronics Converters, Applications, and Design”, John Willey & Sons, Inc., 2nd Edition, 1995.
3. Erickson Robert W., Maksimovic Dragan, "Fundamentals of Power Electronics", Kluwer Academic Publishers Group (Netherlands), 2001.
4. A. Pressman, “Switching Power Supply Design”, McGraw-Hill, 1998.
5. Bin Wu “High-Power Converters and Ac Drives” John Wiley & Sons, Inc., Hoboken, New Jersey.

M. Tech. (Electrical), Semester – I

EEPE103: MODELING OF ELECTRICAL MACHINES AND DC DRIVES

L	T	P	C
3	1	2	5

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain the basic principle of electrical machines and Electric Drives
CO2	Derive the equations for reference frame theory
CO3	Estimate the performance of Induction and Synchronous Machines
CO4	Analyse the performance of DC Drives and Linear Machines
CO5	Apply the reference frame theory on Induction and Synchronous Machines in real life problem.
CO6	Apply the control methods of DC drives and Linear machines in real world.

2. SYLLABUS

- **BASIC PRINCIPLE OF ELECTRICAL MACHINES** **(06 Hours)**
  Introduction, Magnetically coupled circuit, Electromagnetic energy conversion, machine winding and air gap EMF, winding inductance and voltage equations, equation of transformation, Reference-Frame Theory.

- **SYMMETRICAL INDUCTION MACHINES** **(08 Hours)**
  Introduction, voltage and torque equations in machine variables, voltage and torque equations in arbitrary reference frame, Analysis of steady state and dynamic operation.

- **SYNCHRONOUS MACHINES** **(08 Hours)**
  Introduction, voltage and torque equations in machine variables, voltage equations in rotor reference frame, Analysis of steady state and dynamic operation.

- **LINEAR MACHINES** **(09 Hours)**
  Energy conversion, Forces in Electromagnetic Fields, Materials for LEMs, Classifications and Applications of Linear Electric Machines.

- **FUNDAMENTALS OF ELECTRIC DRIVES** **(08 Hours)**
  Introduction, Choice of Electrical Drives, Dynamics of Electrical Drives, Concept of Multi-quadrant operation, Components of load torques, Selection of motor power rating, Speed torque, speed control, Starting, Braking, applications in Industrial and transportation sector.

- **DC DRIVES** **(06 Hours)**
  Modelling, Rectifier fed DC drive, Chopper controlled DC drives, Close loop control of DC drive. Analysis of steady state and dynamic operation.

Total Hours: 45

Note: Tutorials will be conducted separately for 15 hours

3. LIST OF EXPERIMENTS

1. To control the speed of DC motor using dual converter without circulating current.
2. To control the speed of DC motor using chopper.
3. To control the speed of DC motor using 1-Φ full convertor.
4. To control the speed of DC motor using 3-Φ full convertor.
5. To study and simulate Clarke and Park transformations
6. To study and simulate the mathematical model of induction machine using
   (i) arbitrary reference frame
   (ii) rotor reference frame

(iii) synchronously reference frame.

7. To study and simulate the mathematical model of cylindrical rotor synchronous machine
8. To study and simulate the mathematical model of salient rotor synchronous machine

4. BOOKS RECOMMENDED:

1. P. C. Krause, Oreg Wasynczuk, Scott D. Sudhoff P.C.Krause, Oreg Wasynczuk, Scott D. Sudhoff "Analysis of Electric Machinery and drive systems", IEEE Press, 2002.
2. P. S. Bhimbra, "Generalised Theory of Electrical Machines", Khanna Publications, Delhi, 2000.
3. G. K. Dubey, "Fundamentals of Electrical Drives" Narosa, 2nd Edition, 2013.
4. S.K. Pillai, A First Course on Electrical Drives, New Age international publishers,Delhi,2010
5. G.K. Dubey "Power semiconductor controlled Drives",Prentice Hall international, New Jersey, 1989.
6. R. Krishnan, Electric motor drives Modeling, Analysis and Control, Person India Education, Delhi, 2003.
7. Ion Boldea, Linear Electric Machines, Drives, and MAGLEVs Handbook, CRC Press, Taylor & Francis Group, New York, 2017.

M. Tech. (Electrical), Semester – I

EEPE105: SOLAR AND WIND ENERGY CONVERSION AND CONTROL

L	T	P	C
3	0	2	4

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Understand and explain present energy status and renewable energy needs
CO2	Analyse the photovoltaic fundamentals and the photovoltaic applications
CO3	Analyse the wind turbine characteristics and the wind power system generation
CO4	Understand and select different electrical machines and power converters for wind energy generation
CO5	Explain different hybrid renewable energy generation systems and their power control

2. SYLLABUS

- **PRESENT STATUS OF FOSSIL FUELS BASED GENERATION AND NEED FOR RENEWABLES** **(05 Hours)**
  Present status of fossil fuel resources in the world and India, limitations of the fossil fuel electricity generation, need for renewable energy and present status in India.

- **SOLAR PHOTOVOLTAICS DEVICES AND CHARACTERISTICS** **(05 Hours)**
  Review of p-n junction diode, exposure to sunlight, PV characteristics and environmental impact, PV devices and modelling, need for maximum power point tracking.

- **PHOTOVOLTAICS POWER ELECTRONICS CONVERTERS, THEIR CONTROL AND GRID INTEGRATION** **(05 Hours)**
  PV-MPPT algorithms, basic DC-DC converters (buck, boost, buck-boost) and their controls, single-phase and three-phase grid connected PV inverters and their control, design of standalone PV systems for irrigation pump and domestic applications.

- **PHOTOVOLTAIC-BATTERY ENERGY STORAGE** **(05 Hours)**
  Types of batteries, battery terminology, characteristics and modelling, battery charging methods, integrating battery-charge control with MPPT, design of standalone PV-battery system.

- **WIND TURBINES AND CHARACTERISTICS** **(05 Hours)**
  Wind data in terms of speed-frequency distribution, power density-speed duration curves, different wind turbines and their characteristics, wind power and energy computations, components of wind turbine system.

- **ELECTRICAL MACHINES, POWER ELECTRONICS CONVERTERS AND GRID INTERFACE FOR WIND ENERGY** **(06 Hours)**
  Fixed and variable wind speed turbines, induction and synchronous machines for wind energy conversion, different power electronics interface based on full and partial converters, wind-MPPT algorithms, wind-farm configurations.

- **SOLAR AND WIND HYBRID SYSTEMS** **(06 Hours)**
  Hybrid systems and their needs, solar-diesel-battery systems, wind-solar-battery system, solar-wind-fuel cell system and its control.

Total Hours: 45

3. LIST OF EXPERIMENTS

1. To control the speed of DC motor using dual converter without circulating current.

2. To control the speed of DC motor using chopper.
3. To control the speed of DC motor using 1-Φ full convertor.
4. To control the speed of DC motor using 3-Φ full convertor.
5. To study induction motor variable frequency drive.
6. To control the speed of switched reluctance motor (SRM).
7. To study BLDC motor speed control using PWM technique.
8. To study speed control of permanent magnet synchronous motor (PMSM) using DSP based trainer kit.

4. BOOKS RECOMMENDED:

1. Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications, Third Edition, PHI Learning Private Limited, New Delhi, 2015.
2. Weidong Xiao, Photovoltaic Power Systems: Modelling, design and control, First Edition, John Wiley & Sons Limited, NJ USA, 2017.
3. Thomas Ackermann, Wind Power in Power System, John Willey & Sons, 2005.
4. J. K. Nayak and S. P. Sukhatme, Solar Energy - Principles of Thermal Collection and Storage, Fourth Edition, Tata McGraw Hill, New Delhi, 2017.
5. R. Teodorrescu, Marco Liserre and Pedro Rodriguez, Grid Converters for Photovoltaic and Wind Power Systems, First Edition, John Wiley & Sons Limited, UK, 2011.

M. Tech. (Electrical), Semester – I (Elective – 1)

EEPE111: POWER QUALITY DISTURBANCE AND ITS MITIGATION

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain the basic power quality terms and problems
CO2	Analysis of power quality terms and problems
CO3	Estimate the performance of power filters and power factor converters
CO4	Analyse the performance control algorithm
CO5	Apply the techniques and filter devices and power factor converters in real life problem
CO6	Apply the control methods of custom power devices in real world

2. SYLLABUS

- **POWER QUALITY** **(09 Hours)**

  Origin of power quality variation & events, power quality indices, causes and effects of power quality disturbances, Characterization of power quality events & event classification. Power quality measuring instruments, Analysis of Power outages, unbalance, distortions, voltage sag, flickers and load balancing.

- **PROCESSING OF STATIONARY & NON-STATIONARYSIGNALS** **(07 Hours)**

  Stationary signals: Overview of analysis methods, frequency domain analysis and signal transformation, estimation of harmonics & inter-harmonics.
  Non stationary signals: Power quality data analysis methods, discrete STFT for analysing time–evolving signal components, wavelet transform, block–based modelling, Statistics of variations.

- **POWER FACTOR CORRECTION & MITIGATION OF HARMONICS** **(08 Hours)**

  Modelling of networks and components under non-sinusoidal conditions: transmission and distribution systems, power quality problems created by drives and its impact on drives, other nonlinear loads, Power factor improvement techniques, Classification and design of Shunt and Series Passive Compensation, Passive filter-classification, types, operation and design, limitation, Hybrid filters.

- **CUSTOM POWERDEVICES** **(11 Hours)**

  Introduction of DSTATCOM, DVR and UPQC, Classification, Structure, direct and indirect control of power converters, operation, load compensation using DSTATCOM, Generation of reference currents, DVR, UPQC structures, Operating modes, Time domain and frequency domain control, Hybrid filters, application in real world problem.

- **POWER QUALITY ISSUES IN HOME APPLIANCES** **(10 Hours)**

  Power factor correction converters in air-conditioners, fans and pump etc, Switched Mode Power Supply, Welding Power Supply and LED Lighting in Household applications, Other power factor techniques.

Total Hours: 45

3. BOOKS RECOMMENDED:

1.Bollen Math H.J. GUIrene Y.H., “Signal Processing of Power Quality Disturbances”, Wilely Inter science Publication (IEEE Press),2006

2. Bhim Singh, Ambrish Chandra, and Kamal Al-Haddad, Power Quality: Problems and Mitigation Techniques, John Wiley and Sons, United Kingdom, Dec. 2014.

3.Fuchs E.F., Masoum Mohammad A.S, “Power Quality in Power Systems and Electrical Machines”, Elsevier Academic Press,2008.

4.Bollen Math H.J,”Understanding Power quality Problems: Voltage Sags and Interruptions”, IEEE Press (Standard Publishers Distributors),2001.

5. Arindam Ghosh and Gerard Ledwich, Power Quality Enhancement using Custom Power Devices, Springer Science and Business Media, New York, Dec. 2012.

6.Wakileh George J."Power System Harmonics: Fundamentals, analysis and filter Design," Springer,(first Indian reprint) 2007.

7. Hirofumi Akagi, Edson Hirokazu Watanabe and Mauricio Aredes, Instantaneous Power Theory and Applications to Power Conditioning, John Wiley and Sons, New Jersey, March, 2007

8. B. Singh, S. Singh, A. Chandra and K. Al-Haddad, "Comprehensive Study of Single-Phase AC-DC Power Factor Corrected Converters With High-Frequency Isolation," *IEEE Transactions on Industrial Informatics*, vol. 7, no. 4, pp. 540-556, Nov. 2011.

9.S. Singh and B. Singh, "A Voltage-Controlled PFC Cuk Converter-Based PMBLDCM Drive for Air-Conditioners," *IEEE Transactions on Industry Applications*, vol. 48, no. 2, pp. 832-838, March-April 2012.

10. S. Singh, B. Singh, G. Bhuvaneswari and V. Bist, "A Power Quality Improved Bridgeless Converter-Based Computer Power Supply," *IEEE Transactions on Industry Applications*, vol. 52, no. 5, pp. 4385-4394, Sept.-Oct. 2016.

11. Topics related other Research papers from IEEE, IET and science direct etc

M. Tech. (Electrical), Semester – I (Elective – 1)

EEPE113: HIGH POWER CONVERTER TOPOLOGIES AND CONTROL

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain the concept of high power semiconductor devices
CO2	Analysis the front end active converter
CO3	Select the voltage source converter for high power applications
CO4	Apply the PWM techniques for control of VSCs
CO5	Apply the control methods of VSCs

2. SYLLABUS

- **REVIEW OF HIGH POWER SEMICONDUCTOR DEVICES (09 Hours)**

  Introduction, Diodes, Silicon Controlled Rectifiers (SCRs), Gate Turn-Off (GTO) Thyristor, Gate Commutated Thyristor (GCT), Insulated Gate Bipolar Transistor (IGBT), Other Switching Devices, Operation of Series Connected Devices, Main Causes of Voltage Unbalance , Voltage Equalization for GCTs , Voltage Equalization for IGBTs.

- **MULTIPULSE RECTIFIERS (11 Hours)**

  Six-Pulse Diode Rectifier, Series-Type Multipulse Diode Rectifiers: 12,18,24 pulse rectifiers, Separate-Type Multipulse Diode Rectifiers: 12,18,24 pulse rectifiers, Six-Pulse SCR Rectifier, 12-Pulse SCR Rectifier, 18- and 24-Pulse SCR Rectifiers

- **MULTILEVEL VOLTAGE SOURCE CONVERTERS (12 Hours)**

  Two-Level Voltage Source Inverter, Cascaded H-Bridge Multilevel Inverters, Diode-Clamped Multilevel Inverters, Multilevel Flying-Capacitor Inverter, Space Vector PWM control of these converters

- **MODULAR MULTILEVEL CONVERTERS (13 Hours)**

  Converter Configuration, Configuration of Submodules, Comparison of Submodules, Principle of Operation, Pulse Width Modulation Schemes, Classical Control of Modular Multilevel Converter.

Total Hours: 45

3. BOOKS RECOMMENDED:

1. Bin Wu and Mehdi Narimani, “High-power converters and AC drives”, John Wiley & Sons Ltd,, IEEE press 2nd edition 2017.
2. Sixing Du, Apparao Dekka, Bin Wu, and Navid Zargari, “Modular Multilevel Converters: Analysis, Control, and Applications”, John Wiley & Sons Ltd, IEEE press, 1st edition 2018.
3. N. Mohan, T. Undeland and W. Robbins, Power Electronics: Converters Applications and Design, New York:Wiley, 2002.
4. B. K. Bose, Modern Power Electronics and AC Drives, NJ, Upper Saddle River:Prentice-Hall, 2002.
5. J. R. Rodriguez, J. W. Dixon, J. R. Espinoza, J. Pontt and P. Lezana, "PWM regenerative rectifiers: state of the art," in IEEE Transactions on Industrial Electronics, vol. 52, no. 1, pp. 5-22, Feb. 2005, doi: 10.1109/TIE.2004.841149.

M. Tech. (Electrical), Semester – I (Elective – 1)

EEPE115: DIGITAL SIGNAL PROCESSING

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	classify the discrete time signals and systems and analyze the system stability.
CO2	design optimum structures for realizing IIR and FIR systems.
CO3	analyse the signals using frequency domain analysis
CO4	design and implement different types of FIR/IIR filters
CO5	apply signal processing techniques to real situation problems

2. SYLLABUS

- **DISCRETE TIME SIGNALS AND SYSTEMS** **(12 Hours)**

  Classification of discrete time signals and systems, quantization error, stability analysis, correlation, sampling theorem, aliasing, Z-transforms and its application to the analysis of LTI systems, Realization of discrete-time systems: Direct form – I, II, recursive and non-recursive realization.

- **DISCRETE TIME FOURIER TRANSFORM** **(14 Hours)**

  Definition and properties of DTFT and DFT and their inverses, efficient computation of DFT: FFT algorithms: DIT and DIF, Time-domain aliasing, Application of DFT in linear filtering: Overlap and save, Overlap and add methods.

- **DIGITAL FILTERS** **(11 Hours)**

  Concept of filtering, phase and group delays, Design of IIR filters from analog filters (Butterworth and Chebyshev) by impulse invariance and bilinear transformation, Windowing techniques for FIR filter design, Selection of window function based on the specification.

- **APPLICATIONS OF DSP** **(06 Hours)**

  Applications of DSP to power electronics/ power system/ Instrumentation.

Total Hours: 45

3. BOOKS RECOMMENDED:

1. Sanjit Mitra, Digital Signal processing, McGraw-Hill Science/Engineering/Math; 3 edition, 2005.
2. Proakis-Manolakis, Digital signal Processing, 3rd edition, PHI, 2000.
3. Oppenheim-Schetor, Discrete time signal processing, 2nd edition, Prectice Hall, 1997.
4. Schaum's outline: Digital Signal Processing, Monson H. Hayes, McGraw Hill.
5. Introduction to Digital Signal Processing by Jonny R. Johnson, Prentice Hall India Learning Private Limited.

M. Tech. (Electrical), Semester – I (Elective – 1)

EEPE117: MICROCONTROLLER-BASED SYSTEM DESIGN

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Revise basic concepts of 8051 microcontroller and embedded 'C' programming
CO2	Explain architecture of CIP 51 8 bit microcontroller with the advanced features of the controller
CO3	Describe the functionality of Programmable internal and external peripherals of CIP 51.
CO4	Write embedded 'C' code for CIP51 with the exposure of SI Lab IDE.
CO5	Develop microcontroller based prototype for automation, power electronics based electrical systems and other real world problems.

2. SYLLABUS

- **REVIEW OF 8051 ARCHITECTURE AND EMBEDDED 'C' PROGRAMMING (10 Hours)**

  Introduction, 8051 family microcontrollers, hardware architecture, input/output pins, I/O ports and circuits, general purpose registers, special function registers, timers-counters, concepts of interrupts.
  Variables and constants, storage classes, enumerations and definitions, I/O operations, control statements, functions, pointers and arrays, structure and unions, interrupt service routines.

- **INTRODUCTION TO CIP-51 CONTROLLER ARCHITECTURE (10 Hours)**

  Memory Map, Instruction Pipeline, PLL & Clock System, concept of Crossbar and Pin assignment, On Chip Peripherals: Timer/Counters, GPIO, ADC, DAC, UART.

- **HARDWARE CONCEPTS AND PROGRAMMING OF CIP-51 PERIPHERALS (14 Hours)**

  Comparator, SPI & I2C serial Communication interface, MAC unit on CIP-51, Programming of PCA, ADC, DAC. Interfacing of seven-segment LED, LCD display, relay, Pushbutton keys, Matrix key board and Stepper motor.

- **APPLICATIONS (11Hours)**

  Design of digital Multimeter, numerical relay, control of DC – DC Converters, DC-AC inverters,

Total Hours: 45

3. BOOKS RECOMMENDED:

1. Muhammad Ali Mazidi, Rolin McKinlay and Janice Gillispie Mazidi "The 8051 Microcontroller and Embedded Systems: Using Assembly and C" Pearson 2nd edition, 2007.
2. M. Mazidi, J. G. Mazidi and R. D. McKinlay, The 8051 Microcontroller and Embedded Systems, Prentice Hall of India, 3rd edition, 2007.
3. Mark Siegesmund, Embedded C Programming: Techniques and Applications of C and PIC MCUS, Elsevier Science, 1 st Edition 2014.
4. Chew Moi, Gourab Sen Gupta "Embedded Programming" Silicon Labs 8-bit MCUniversity Program.
5. Datasheet of SILABS C8051FXXX. (www.silabs.com)
6. Application notes from SILAB C8051FXXX.

M. Tech. (Electrical), Semester – I (Elective – 1)

EEPE119: PHYSICAL PHENOMENA OF ELECTRICAL MACHINES

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	To explain the basic understanding of electrical machines
CO2	To analyze the operation of induction machines
CO3	To analyze performance parameters of electrical machines
CO4	To analyze the performance synchronous machine
CO5	Performance and analysis of the electrical machines in real world application

2. SYLLABUS

- **BASIC UNDERSTANDING OF ELECTRICAL MACHINES** **(11 Hours)**

  Voltage and torque equation of electrical machines, Stray load losses, Oscillation, Vector and matrix power, linear transformation, magnetic and electric energy storage, forces, space harmonic and time harmonics, suppress space harmonics: skewing and fractional slot winding, Cause of vibration and noise, other physical phenomena.

- **INDUCTION MACHINE** **(12 Hours)**

  Single phase and three phase induction circle diagram, calculation in the region of standstill, calculation in the region of maximum torque, symmetrical components transformation- current and voltage, unbalanced operation, Dynamic braking, operation as generator, winding, losses, Rotor types- deep rotors, idle rotors, double squirrel cage rotor, starting current limitation, temperature limitation, rating and applications.

- **PHENOMENA OF CRAWLING, STRAY LOSSES, LOCKING, NOISE AND RIPPLES AND OTHERS** **(11 Hours)**

  Effect of harmonics field, Permeance waves, crawling- asynchronous and synchronous, stray losses, standstill locking, magnetic pull, Parasitic torque, Nature of noise, calculation, induced voltage ripple, Effect of harmonics in the impresses voltage, cogging and synchronous crawling, Physical phenomena and their effect on ac and dc machines.

- **SYNCHRONOUS MACHINE** **(11 Hours)**

  Balanced steady state operation, pull in phenomena, Transient and unbalance operation, Alternator operation– parallel and isolation, Hunting, Measurement of machine parameters, sudden short circuit, three phase short circuit, Elimination of field winding, Zero power factor test, toque, elimination of damper winding, line to line load, line to neutral load.

Total Hours: 45

3. BOOKS RECOMMENDED:

1. Philip L. Alger, "Induction machines -Their Behavior and uses" Second edition, Gordon and Breach science publishers, New York, 1970.
2. Charles V. Jones, "The unified theory of Electrical Machines," Butter worths publication, London, 1967.
3. P.S. Bimbhra, Generalized theory of electrical Machines, Khanna Publishers, Delhi, 1996.
4. M.G.SAY, The Performance and Design Of Alternating Current Machines, CBS Publishers and Distributors, Delhi,2002
5. P. Vijayraghavan and R. Krishnan, "Noise in electric machines: a review," Conference Record of 1998 IEEE

Industry Applications Conference. Thirty-Third IAS Annual Meeting (Cat. No.98CH36242), St. Louis, MO, USA, 1998, pp. 251-258 vol.1.
6. S. P. Verma, “Noise and vibrations of electrical machines and drives; their production and means of reduction,” Proceedings of International Conference on Power Electronics, Drives and Energy Systems for Industrial Growth, New Delhi, India, 1996, pp. 1031-1037 vol.2.
7. Other related research publication from IEEE, IET and science direct etc.

M. Tech. (Electrical), Semester – I (Elective – 2)

EEPE131: ADVANCED NUMERICAL METHODS AND APPLICATIONS

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	learn various advanced numerical methods.
CO2	apply the numerical methods for solving problems related to electrical engineering.
CO3	modeling various systems and perform regression analysis.
CO4	analsye the convergence rate and stability of the algorithms
CO5	Select a suitable numerical method for solving the real time problems based on the accuracy, speed and stability.

2. SYLLABUS

- **ERROR ANALYSIS** **(05 Hours)**

  propagation of error, fixed point and floating point algorithms, reminder theorem

- **SOLUTION OF SYSTEM OF NONLINEAR EQUATIONS** **(06 Hours)**

  Newton-Raphson method, Method of Successive approximation, Adomian decomposition method, convergence criterion

- **REGRESSION ANALYSIS** **(12 Hours)**

  Least Square criterion (LSq), two-dimensional regression for linear and nonlinear systems, multi-dimensional regression for linear and nonlinear systems

- **SOLUTION TO ORDINARY DIFFERENTIAL EQUATIONS** **(12 Hours)**

  Single-step and multi-step explicit integration algorithms – Adam's Bashforth formula, multi-step implicit integration algorithms – Adam's Moulton formula, stability analysis.

- **SOLUTION TO PARTIAL DIFFERENTIAL EQUATIONS** **(05 Hours)**

  Specification of initial and boundary conditions, Solution by finite difference method

- **INTRODUCTION TO INTEGRAL EQUATIONS** **(05 Hours)**

  Homogenous and non-homogenous integral equations, numerical methods to solve solution to integral equations

Total Hours: 45

3. BOOKS RECOMMENDED:

1. Shastri S. S., “Introductory Methods of Numerical Analysis”, Prentice Hall Ltd., 4th Edition, 2005.
2. Jain M. K., Iyengar S.R.K., Jain R.K., “Numerical Methods for Scientific and Engineering Computation”, 4th Edition, 2003, New Age international Publishers, Pvt. Ltd.
3. S. D. Conte and Carl de Boor, Elementary Numerical Analysis an Algorithmic Approach, 3rd Edition, McGraw-Hill, 1980.
4. Pallab Ghosh, “Numerical Methods with Computer Programs”, in C++, Printice Hall of India Private Ltd., 2006.
5. Teukolsky S. A., Vetterling W. T., Press W. H. & Flannery B. P., "Numerical recipes in ‘C’, 2nd Edition, Foundation Books Pvt. Ltd., 2001.
6. Leon O. Chua and Pen-Min Lin, “Computer-Aided Analysis of Electronic Circuits”, Printice Hall Series in Electrical and Computer Engineering.

M. Tech. (Electrical), Semester – I (Elective – 2)

EEPE133: SYSTEM THEORY

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	understand the concepts of vector spaces and subspaces
CO2	explain the concepts of Linear algebra and its application to control theory
CO3	analyze discrete time systems with Z-transforms
CO4	evaluate the stability of discrete time systems and obtain the state space representation of discrete time systems
CO5	design controllers and observers for discrete time systems

2. SYLLABUS

- **LINEAR ALGEBRA** **(22 Hours)**

  Vector spaces, Basis, Operator, range of the linear operator, null space, rank, nullity, rank-nullity theorem, matrix representation of the linear operator in the bases, orthogonal bases, Inner product spaces, Holder inequality, Cauchy-Schwartz inequality, triangular inequality, Minkowski inequality, best approximation theorem , orthogonal projection lemma, Gram- Schmidtt orthogonalization, Characteristics polynomial, minimal polynomial, eigen value and eigen vector, Diagonal form, Triangular form, Caley- Hamilton Theorem.

- **SYSTEM THEORY** **(23 Hours)**

  Introduction to Z transformation ,bilateral and unilateral Z transformation, Z transformation of the important signals, Solving Discrete LTI system using Z transformation, Pulse transfer function, Phase space analysis of the discrete LTI system, Jury Stability criterion , Schur-Cohn test, Bilinear transformation applied with Routh's stability criterion. Conservative system, Controllability, Obsrvability, Observer Design, Diaphantile equation, Full order, reduced order, minimum order observer, Gopinath Observer, Luenberger Observer.

Total Hours: 45

3. BOOKS RECOMMENDED:

1. Kenneth Hoffmann And Ray Kunze, "Linear Algebra", PHI India limited, 1971.
2. K. Ogata, "Discrete-Time Control Systems", Prentice Hall; 2nd edition, 1995.
3. Allen V. Oppenheim, S. Willsky, with S. Hamid Navab ''Signals and systems" Prentice Hall; 2nd edition, 1996.
4. K. Ogata, "Modern Control Engineering", 3rd Edition, PHI India limited, 2001.
5. I. J. Nagrath and M. Gopal, "Control System Engineering", Anshan Publishers; 5th edition, 2008.

M. Tech. (Electrical), Semester – II (Elective – 2)	**L**	**T**	**P**	**C**
EEPE 135: CONTROL TECHNIQUES IN SWITCH-MODE POWER CONVERTERS	**3**	**0**	**0**	**3**

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain different modulation techniques for power converters
CO2	Modeling DC-DC converters applying State-space and Circuit averaging techniques
CO3	Design and analyze voltage-mode control of DC-DC converters
CO4	Design and analyze current-mode control of DC-DC converters
CO5	Design and analyze nonlinear control of DC-DC converters

2. SYLLABUS

- **MODULATION TECHNIQUES** **(06 Hours)**

  Fixed-frequency modulation techniques: Trailing-edge PWM, Leading-edge PWM, Dual-edge PWM and Phase-shift PWM. Variable frequency modulation techniques: Constant on-time modulation, constant off-time modulation and hysteresis modulation.

- **DYNAMIC MODELLING OF CONVERTERS** **(12 Hours)**

  State-Space Averaging Technique: Deriving large-signal averaged equations for dc-dc converters, perturbation and linearization, construction of small-signal averaged equivalent circuit model, modeling the pulse-width modulator, state-space averaged models for various dc-dc converters.
  Circuit-Averaging and Averaged Switch Modeling: Deriving large-signal average model of switching network, perturbation and linearization, construction of small-signal averaged equivalent circuit of basic dc-dc converters. Advantages with circuit-averaging modeling over state-space averaging technique. Transfer functions of DC-DC converters..

- **VOLTAGE-MODE CONTROL** **(09 Hours)**

  Converter's objectives and control requirements, voltage mode control design for basic dc-dc converters using loop shaping technique, stability margins: gain and phase margins, disturbance rejection using feedforward technique, combined feedback and feedforward control.

- **CURRENT-PROGRAMMED CONTROL** **(09 Hours)**

  Concept of Current-programmed mode (CPM) control, Modelling of converter operating in CPM: a simple first-order model, drawback with first-order model, a more accurate model, Converter transfer functions with CPM control, Addition of an input filter to current-programmed converter, Simulation of CPM controlled converters, Voltage feedback loop around a current programmed converter, Loop interactions in CPM control and design of average current mode control.

- **NONLINEAR CONTROL** **(09 Hours)**

  Model based classification of Nonlinear control methods, Small-signal and large-signal model based nonlinear control, Sliding mode control, Sliding mode control design in a buck converter, boundary control techniques and selection of switching surfaces, boundary control design for a buck converter, linking switching boundary and conventional PID control to improve performance of DC-DC converters.

Total Hours: 45

3. BOOKS RECOMMENDED:

1. Robert Erickson, D. Maksimovic, ``Fundamental of Power Electronics, 3rd edition, Springer Nature Switzerland AG 2020.
2. Philip T. Krein, ``Elements of Power Electronics'', Oxford University press, Indian Edition 2017.
3. Christophe P. Basso, Designing Control Loops for Linear and Switching Power Supplies: A Tutorial Guide, Artech House Publishers, 1 Oct 2012.
4. Santanu Kapat, `` Control and Tuning Methods in Switch Mode Power Converters'', Online Video lectures on NPTEL India.

M. Tech. (Electrical), Semester – I (Elective – 2)

EEPE137: DESIGN OF MAGNETIC COMPONENTS FOR POWER CONVERTERS

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	explain the basic concept of magnetics
CO2	devise various design steps for inductor and transformers
CO3	Formulate area product for high frequency transformers for different isolated dc-dc converters
CO4	Design of high frequency transformers
CO5	devise the computer aided simulation for design of high frequency transformers

2. SYLLABUS

- **PRINCIPLES OF MAGENTIC THEORY** **(10 Hours)**

  Review of basic magnetics, transformer modelling, loss mechanism in magnetic devices, eddy current in winding conductors, several types of magnetic devices, their B-H loops and core vs copper loss, Magnetic materials- core materials, core shapes, core size, core assembly

- **DESIGN OF INDUTCORS** **(06 Hours)**

  Principles of inductor design, filter inductor design constraints, step by step procedure, multiple winding magnetics design, ac inductor design, coupled inductor design

- **PRINCIPLES OF TRANSFORMER DESIGN** **(10 Hours)**

  Introduction to Power Transformer- operation on no-load and load, hysteresis loss, remnant flux density, induced emf and eddy currents, turns ratio, volt-sec product, stack factor, leakage flux, equivalent circuit, power handling capacity of the transformer, area product, choice of core for the a transformer, window utilization factor, transformer polarities and dot convention, testing of polarity.

- **HIGH FREQUENCY TRANSFORMER DESIGN** **(10 Hours)**

  Area products of transformer for isolated dc-dc converters like forward, half bridge, full bridge, push-pull, and fly-back, design of transformers for aforesaid isolated dc-dc converters, design of multiple outputs transformer.

- **DESIGN OF CURRENT TRANSFORMERS** **(04 Hours)**

  Principles of bidirectional CT design, Design steps in CT, unidirectional CTS

- **COMPUTEWR AIDED DESIGN OF TRANSFORMERS** **(05 Hours)**

  Module 1-Specifications, module2- Transformer design, design data output

Total Hours: 45

3. BOOKS RECOMMENDED:

1. L. Umanand and S.R. Bhat, “Design of magnetic Components for switched mode power converters”, Wiley Eastern Limited, 1st Edition.
2. Ned Mohan et al, “Power Electronics: Converters, Applications, and Design”, John Wiley & Sons. Inc., 3rd Edition, 2010.
3. R.W. Erickson, Fundamental of Power Electronics, Springer (India) Private limited 2005.

M. Tech. (Electrical), Semester – I (Elective – 2)
EEPE139: ELECTRIC VEHICLE TECHNOLOGY

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Understand the basic concepts of electric vehicles and popular traction systems
CO2	Analyze the different propulsion unit and their working
CO3	Understand the drive-train topologies and advanced propulsion techniques
CO4	Analyze the various energy storage methodologies in traction systems
CO5	Understanding the Energy Management in Electric Vehicle

Pre- requisites:
1. Control Systems 2. Electrical Machines 3. Power Electronics. 4. Electric Drives.

2. SYLLABUS

- **CONVENTIONAL VEHICLES** **(09 Hours)**
  Vehicle dynamics, Basics of vehicle performance, vehicle power source characterization, transmission characteristics and mathematical models to describe vehicle performance. Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drivetrains on energy supplies.

- **HYBRID ELECTRIC DRIVETRAINS** **(12 Hours)**
  Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Electric Drive-trains; Basic concept of electric traction, introduction to various electric drive-train topologies. Power flow control in electric drive-train topologies, efficiency analysis, Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE) Sizing the propulsion motor, sizing the power electronics.

- **ELECTRIC PROPULSION UNIT** **(10 Hours)**
  Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, Switch Reluctance Motor drives, drive system efficiency.

- **ENERGY STORAGE** **(07 Hours)**
  Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based, Fuel Cell based, Super Capacitor based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE) Sizing the propulsion motor, sizing the power electronics selecting the energy storage technology, Communications, supporting subsystems

- **ENERGY MANAGEMENT ISSUES** **(07 Hours)**
  Classification and comparisons of different energy management strategies, implementation issues of energy management strategies, Case Studies: Design of a Hybrid Electric Vehicle (HEY), Design of a Battery Electric Vehicle (BEV).

Total Hours: 45

3. BOOKS RECOMMENDED:

1. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 2014.
2. Iqbal Hussein Electric and Hybrid Vehicles: Design Fundamentals, CRC Pres, 2003.
3. Mehrdad Ehsani, Yi.mi Gao Sebastjan E. Gay, Ali Emadi , Modem Electric, Hybrid Electric and Fuel Cell Vehicles; Fundamentals Theory and Design, CRC Press 2004.

4. James Larminie John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
5. S. Onorio, L. Serrao and G. Rizzoni, 'Hybrid Electric Vehicles: Energy Management Strategies", Springer 2015.
6. T. Denton, ‘Electric a.ad Hybrid Vehicles’, Routledge 2016.

M. Tech. (Electrical), Semester – I (Elective-2)

EEPE141: ADAPTIVE CONTROL AND SOFT COMPUTING

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain the basic principle of adaptive control
CO2	Explain the basic principle of soft computing
CO3	Understanding of adaptive filter and LMS
CO4	Analyse and control of ANN and Fuzzy based system
CO5	Performance of the Adaptive system with real world problem
CO6	Performance of the soft computing with real world problem

2. SYLLABUS

- **ADAPTIVE CONTROL** **(22 Hours)**

  Adaptive Schemes, Adaptive Control Problem; Applications, Regression Models, Recursive Least Squares, Real-Time Parameter Estimation, Direct and Indirect Self-Tuning Regulators Pole Placement Design, MDPP, Model Reference Adaptive Systems, MIT Rule, Design of MRAS Using Lyapunov Theory, PI and PID controller-conventional and auto gain tuning, Parameter Identifiers and Adaptive Observers- Luenberger Observer and others, Parameter estimation algorithms and its application, Adaptive filter-Method of steepest descent, stability, least mean square adaptive filter, comparison, convergence and robustness, Methods of least mean square, applications.

- **SOFT COMPUTING** **(23 Hours)**

  Introduction, ANN models; Feed Forward Network; Radial Basis Function; Learning process; Supervised and unsupervised learning- adaptive neural network, back propagation, RBFN, Kohonen self-organizing Maps, LVQ; Least mean square algorithm; Back propagation algorithm; Applications in pattern recognition and other engineering problems; Case studies; Identification and control of linear and nonlinear systems; Fuzzy set operations and concept; Fuzzy control systems; fuzzy rules, reasoning and inference system , Classical fuzzy control problems; Genetic Algorithm; Adaptive fuzzy systems; Hybrid Systems; Application of soft computing techniques in physical systems.

Total Hours: 45

3. BOOKS RECOMMENDED:

1. Karl Johan Astrom and Bjom Wittenmark, "Adaptive Control", Second edition, Dover Publication Inc.,Mineila, New York,1995
2. Shankar Sastry and Marc Bodson , "Adaptive Control: Stability, Convergence and Robustness", PHI- Prentice Hall Information- Prentice Hall Advanced Reference Series (Eastern Economy Edition), 1989
3. Karl Johan Astrom, "Adaptive Control", Pearson Education, 2001.
4. Petros A Loannou, Jing, "Robust Adaptive Control" Prentice-Hall, 1995.
5. Benjamin C. Kuo, Automatic Control System, PHI learning Private limited, Delhi, 2013.
6. Simon Haykin , Adaptive filter Theory, Pearson education Inc., Delhi, 2002.
7. Jang, T. Sun and E. Mizutani, "Neuro-Fuzzy and Soft computing: a computational approach to learning and machine intelligence", Pearson Education Inc, Delhi, 1997.
8. S.N. Sivanandam and S.N. Deepa, "Principles of soft computing, 2ed edition, Wiley India, New Delhi, 2011.
9. G. J. Klir, Boyuan, Fuzzy sets and fuzzy logic, Prentice Hall of India (P) Ltd, 1997.
10. Vose Michael D., Simple Genetic Algorithm - Foundations and Theory, Prentice Hall of India.

Hands-on training FPGA based Control of Power Electronic Converters

B. Tech. III (EE), Smester VI (**EEV06**) M. Tech. **(EEPE91)** **Hands-on training: FPGA based Control of Power Electronic Converters**	**Scheme**	**L**	**T**	**P**	**Credit**
		0	**0**	**10**	**5**

Course outcomes:

At the end of this course the students will be able to

CO1	write programs using Verilog HDL code.
CO2	simulate the programs using integrated development environment (IDE).
CO3	interface the FPGA with external hardware using ADC/DAC.
CO4	generate gate pulses to control various power electronic converters.
CO5	develop a laboratory prototype of FPGA based controller for PE converters.

•	**Introduction** Review of digital logic circuits, Different kinds of programmable logic devices: Field Programmable Gate Array (FPGA), Programmable Logic Device (PLD), FPGA manufacturers (Xilinx, Altera, Actel, Lattice Semiconductor, Atmel). FPGA applications. Adjoining devices. Instruments and software.	2 Hours
•	**The Structure of FPGA** FPGA general description. Different kinds of FPGA packages. FPGA architecture. Internal hard modules of FPGA (CLB, Block RAM, DCM), their meanings and usage. Different kinds of I/O modules, their usage and configuration	4 Hours
•	**FPGA Design Flow** Architecture design. Project design using Verilog Hardware Description Language (HDL). Defining testing methodology and test bench design. RTL simulation, synthesizing, implementation, gate level simulation of design. Reusing of internal hard modules during design and implementation.	6 Hours
•	**FPGA Configuration and Testing Methodology** Different types of FPGA configuration files. Generation of configuration file and its loading into FPGA. Functional and gate level testing. SDF file description and usage.	8 Hours

Laboratory experiments:

Sl. No.	**Name of the Experiment**	**Hours**
1.	Introduction to integrated development environment (IDE) for system Verilog	6

2.	Getting acquainted with Verilog programming (i) Full adder, (ii) Up-down counter (iii) LED blink (iv) LCD display	10
3.	Interfacing using GPIO pins	6
4.	Generation of Arbitrary waveforms using Look up table (LUT)	10
5.	ADC/DAC interfacing	10
6.	Open-loop control of DC-DC converters (i) Buck (ii) Boost (iii) Buck-boost	10
7.	Square wave operation of Single-phase inverter (i) Half- Bridge with R and R-L load (ii) Full- Bridge with R and R-L load	8
8.	Single phase AC voltage controller with R and R-L load	8
9.	Operation of three phase inverter in 120° and 180° conduction modes	8
10.	Generation of gating pulses using Sine PWM technique	8
11.	Transformation from 3-phase to 2-phase	8
12.	Transformation from 2-phase to arbitrarily rotating reference frame	8
13.	Mini Project	50
14.	Continuous Evaluation	30
	Total (Notional Hours)	200

Books Recommended:

1. "Verilog HDL", A guide to Digital Design and Synthesis Samir Palnitkar SunSoft Press 1996.
2. P. Chu Pong, "FPGA Prototyping by Verilog Examples", Xilinx Spartan, 3rd version, 2008
3. DE1-SoC Getting started Guide for ALTERA Cyclone V GX, " https://www.terasic.com.tw/cgi-bin/page/archive.pl?Language=English&CategoryNo=165&No=836&PartNo=4#contents"

4. NPTEL video Lectures on "Hardware modelling using Verilog by Prof. Indaranil Sengupta, IIT Kharagpur".

M. Tech. (Electrical), Semester – II

EEPE102: POWER ELECTRONICS – II

L	T	P	C
3	1	2	5

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	learn different topologies of PFC converters and analyse them
CO2	model the PFC converters converter and design the controller
CO3	classify and analyze different types of resonant converters
CO4	classify and analyze various multi-level inverters and ZS Inverters
CO5	Design driver circuits, magnetic components and heat sink for devices in the converters

2. SYLLABUS

- **UNITY POWER FACTOR CONVERSION** **(07 Hours)**

  Topologies, Steady-state Analysis, Dynamic Analysis, Matrix converters, Modeling and Applications

- **RESONANT CONVERTER** **(10 Hours)**

  Introduction, Classification, Basic Resonant Circuit Concepts, Load Resonant Converter, Resonant Switch Converter, Zero Voltage and Zero Current Switching, Clamped Voltage Topologies, Resonant DC link Inverter, High Frequency Link Integral Half Cycle Converters.

- **Z-SOURCE INVERTERS** **(06 Hours)**

  Z-source networks, Z-source Inverters, Quasi-Z-Source Inverters, Applications

- **MULTI LEVEL CONVERTERS** **(12 Hours)**

  Principle, Topologies: DCMLI, FCMLI, CHBMLI, Multi-level rectifiers, Control and applications

- **DESIGN CONSIDERATIONS** **(08 Hours)**

  Gate-drive circuit design, Design of snubber circuit, design of magnetic components: inductor, high-frequency transformers, line and EMI filters, Heat sink design

Total Hours: 45

Note: Tutorials will be conducted separately for 15 hours

3. LIST OF EXPERIMENTS

SET - I

1. Study of single phase boost active power factor correction.
2. Study of 3-level Diode Clamped multi-level Inverter circuit.
3. Study of Series Resonant Converter.
4. Study of 12 pulse controlled and uncontrolled rectifier.
5. Study of Thyristorised APFC [Active Power Factor Correction] circuit.
6. Study of Dynamic Voltage Regulator.
7. Study of Push-Pull converter.
8. Study of open loop and closed loop response of DC-DC flyback converter.

SET – II

1. Simulation of Boost Converter based PFC circuit using control method: (i) Average Current Control; (ii) Peak Current Control; and (iii) Hysteresis Current Control.
2. Simulation of Resonant Converter Circuits: Series, Parallel.
3. Simulation of Multi Pulse Converter: (i) 12 pulse; (ii) 18 pulse; and (iii) 24 pulse.
4. Simulation of Multi-level Inverter: (i) 3-level; and (ii) 5 level.
5. Simulation of PWM rectifier.
6. Simulation of PWM AC Chopper circuit.

SET – III

1. Mini Project

4. BOOKS RECOMMENDED:

1. Rashid, M. H., "Power Electronics Handbook", Elsevier Academic Press, 2001.
2. Ned Mohan, Tore M. Undeland and William P. Robbins, “Power Electronics Converters, Applications, and Design”, John Willey & Sons, Inc., 2nd Edition, 1995.
3. Erickson Robert W., Maksimovic Dragan, "Fundamentals of Power Electronics", 2nd Edition, Springer New York.
4. Umanand “Power Electronics: Essentials & Applications” Wiley, 2009
5. Bin Wu, “High-Power Converters and Ac Drives” John Wiley & Sons, Inc., Hoboken, New Jersey.
6. Ersan Kabalcı “Multilevel Inverters Introduction and Emergent Topologies”, Elsevier Science, 2021.

L	T	P	C
3	1	2	5

M. Tech. (Electrical), Semester – II

EEPE104: AC DRIVES

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain the basic principle of induction and synchronous Drives
CO2	Derive the equations and design of AC motors
CO3	Estimate the performance of Induction and Synchronous Machines
CO4	Analyse the performance of AC Drives
CO5	Apply the Induction and Synchronous Machines in real life problem
CO6	Apply the control methods of AC drives in real world.

2. SYLLABUS

- **INDUCTION MOTOR DRIVES** **(23 Hours)**

  Introduction, Review of three phase I.M. analysis and performance, Analysis of I.M. fed from Non-sinusoidal supply voltage, Stator voltage control, V/f controlled induction motors, Close loop control, Slip power recovery-static scherbius and Kramer drives, PWM switching schemes, Field oriented control-direct and indirect control, Parameter sensitivity, Flux programming efficiency optimizer, stator flux oriented vector control, Sensor-less vector control-speed estimation methods, Direct torque and flux control (DTC), Parameter estimations, Applied adaptive and intelligent Control- Fuzzy and neural network, hybrid methods, Multilevel inverter fed drives and control, CSI fed induction motor drives, Applications.

- **SYNCHRONOUS MOTOR DRIVES** **(22 Hours)**

  Introduction, Sinusoidal SPM machine drives- open loop V/F control, vector control , Synchronous reluctance machine drives-current vector control, Sinusoidal IPM machine drives-vector control with maximum torque /ampere, field weakening, Vector control with stator flux orientation- feed-back signal processing, PWM square wave sequencing, Trapezoidal SPM machine drive- $2\pi/3$ angle switch on mode, voltage and current control PWM mode, torque pulsation, Wound field synchronous motor drive, Load-commutated Synchronous Motor Drives- Delay angle control, Sensor less control- Trapezoidal SPM machines, sinusoidal PM machines, PWM switching schemes, Switch reluctance motor drives: Operation, Power Converters, Control of SRM- current, flux and torque, acoustic noise and its control, sensor less control, Applications, Application of intelligent Control-Fuzzy and neural network, hybrid methods method.

Total Hours: 45

Note: Tutorials will be conducted separately for 15 hours

3. LIST OF EXPERIMENTS

1. Speed control and performance analysis of voltage source inverter fed three phase induction motor drives.
2. Speed control and performance analysis of multilevel inverter fed induction motor drives.
3. Speed control and performance analysis of PMSM drives
4. Speed control and performance analysis of synchronous reluctance drives.
5. Study of variable frequency drives.
6. Speed control and performance analysis of switch reluctance motor drives
7. Speed control and performance analysis of IPM drives
8. Close loop control of induction motor drives.
9. Close loop control of synchronous motor drives.
10. Generator Operation of induction machine.

11. Performance study of PMSG.

4. BOOKS RECOMMENDED:

1. B.K.Bose, “Modern Power Electronics and AC drives” Pearson Education Asia, 2003.
2. R. Krishnan, “Electric motor drives Modeling, Analysis and Control” PHI-India, 2005.
3. R. Krishnan, “Switched Reluctance Motor Drives Modeling, Simulation, Analysis, Design, And Applications,”CRC Press, New York, 2015.
4. Tze-Fun Chan and Keli Shi, “Applied Intelligent Control of Induction Motor Drives”, John Wiley & Sons, Singapore, 2011
5. S.K. Pillai, “A First Course on Electrical Drives”, New Age international publishers, Delhi, 2010.
6. G.K. Dubey, "Power semiconductor controlled Drives", Prentice Hall international, New Jersey, 1989.
7. Dewan, S. Slemon B., Straughen, A. G.R., "Power Semiconductor drives", John Wiley and Sons, NewYork 1984.
8. Rashid, M. H., "Power Electronics Handbook", Elsevier Academic Press, 2001.

M. Tech. (Electrical), Semester – II (Elective – 3)

EEPE 112: CHARGING INFRASTRUCTURE FOR ELECTRIC VEHICLES

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	explain the basic concept of EV battery charging
CO2	devise various power electronic converters to EV battery chargers
CO3	devise different control techniques for EV battery charging
CO4	explain the different types of connectors
CO5	decide the suitability of EV chargers for applications in emerging areas

2. SYLLABUS

- **ELECTRIC VEHICLE CHARGING INFRASTRUCTURE** **(12 Hours)**

  History of EV, Components of Electric Vehicle, Comparison with Internal combustion Engine : Technology, Comparison with Internal combustion Engine: Benefits and Challenges, EV classification and their electrification levels, EV Charging Technology-Electric Vehicle Supply Equipment (EVSE), types of EVSE, Options for EV Charging, Charger Specifications and PCS Infrastructure, Location of PCS/ FCB CS in local area/ building precincts

- **TYPES OF EV CHARGERS** **(10 Hours)**

  Electric Vehicle Technology and Charging Equipments, Basic charging Block Diagram of Charger, Difference between Slow charger and fast charger, Slow charger design rating, Fast charger design rating, AC charging and DC charging, On-board and off-board charger specifications, EVSE associated charge times calculation

- **SELECTION AND SIZING OF COMMON TYPES OF CONNECTORS AND APPLICATIONS** **(12 Hours)**

  Selection of AC charger type-1, type -2 and type -3, Communication between AC charger and EV Selection of DC charger connector GB/T, CHAdeMO, CCS-1 and CSS-2, Communication methodology of DC fast chargers, IS/ IEC/ARAI/ standard of Charging topology ,Communication and connectors (IEC 61851-1, IEC 61851-24,62196-2), Selection sizing of Charger connector cable

- **ADVANCED EV CHARGERS WITH MULTIFUNCTIONAL FEATURES** **(11 Hours)**

  EV Chargers with bidirectional power flow capability, Multifunctional operation-G2V, V2G, V2V, V2L etc.

Total Hours: 45

3. BOOKS RECOMMENDED:

1. Iqbal Hussein Electric and Hybrid Vehicles: Design Fundamentals, CRC Pres, 2003.
2. S. Onorio, L. Serrao and G. Rizzoni, 'Hybrid Electric Vehicles: Energy Management Strategies", Springer 2015.
3. Ottorino Veneri, Technologies and Applications for Smart Charging of Electric and Plug-in Hybrid Vehicles, Springer, 2017
4. Sobodh Sarkar, Electric Vehicle Service Equipment - EVSE - Comprehensive Design Inputs of Level 1,2 & 3 Chargers: Circuits, Design & Infrastructure of EVSE, 2019

M. Tech. (Electrical), Semester – II (Elective – 3)

EEPE 114: SPECIAL ELECTRICAL MACHINES AND DRIVES

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain the basic principle of Special Machines Drives
CO2	Derive the equations and design of Special Machines Drives
CO3	Estimate the performance of Special Machines
CO4	Analyse the performance of Special Machines
CO5	Apply the special machines in real life problem
CO6	Apply the control methods of special machines in real world

2. SYLLABUS

- **STEPPING MOTORS** **(08 Hours)**

  Constructional features, principle of operation, Types of stepper motors: VR Stepper motor, PM stepper motor, Hybrid stepper motor, torque production in VR stepper motor, modes of excitation, Dynamic characteristics, Drive systems and circuit for open loop control, Closed loop control of stepping motor, Design and Applications.

- **SWITCHED RELUCTANCE MOTORS** **(08 Hours)**

  Constructional features, principle of operation, design, steady state performance, methods for inductance calculation, Torque equation, Power converters, speed torque characteristics, closed loop control for Switched Reluctance drives, current and torque control, acoustic noise control, sensor-less operation, applications.

- **PERMANENT MAGNET BRUSHLESSDC MOTORS** **(08 Hours)**

  Commutation in DC motors, difference between mechanical and electronic Commutators, Hall sensors, Optical sensors, Multi phase Brushless motor, Square Wave permanent magnet brushless motor drives, torque and EMF equation, torque speed characteristics of Permanent Magnet Brushless DC Motors- controllers PMDC Motor, sine wave permanent magnet brushless motor drives, Applications.

- **SERVO MOTORS** **(04 Hours)**

  Symmetrical components applied to two - phase servo motors - equivalent circuit and performance based on symmetrical components - servo motor torque - speed curves.

- **FRACTIONAL KILOWATT MOTORS** **(04 Hours)**

  universal motor, reluctance motor, hysteresis motor, repulsion motor, essential parts, torque - characteristics, design and control, and applications.

- **LINEAR MACHINES** **(06 Hours)**

  Linear Induction Motors-Theory and performance, design for medium to high speed, Superconducting Magnet Linear Synchronous Motors, Linear Reluctance Synchronous Motors and Applications.

- **MACHINE DESIGN** **(06 Hours)**

  Fundamentals of machine design, Design philosophy, Materials, Stresses in machines, Machine design using FEM package.

Total Hours: 45

3. BOOKS RECOMMENDED:

1. Miller. T.J.E., “Brushless Permanent Magnet and Reluctance Motor Drives”, Clarendon Press, Oxford, 1989.
2. Kenjo. T and Nagamori. S, ”Permanent Magnet and Brush less DC Motors", Clarendon Press, Oxford,1989.
3. Kenjo.T, "Stepping Motors and their Microprocessor Control", Clarendon Press, Oxford, 1989.
4. Krishnan R. "Switched Reluctance Motor Drives", Modelling, Simulation, Analysis, Design and applications, CRC press, 2006.
5. Hughes, “Electric Motors & Drives”, Newnes; 3rd edition,2005.
6. Ion Boldea, Linear Electric Machines, Drives, and MAGLEVs Handbook, CRC Press, Taylor & Francis Group, New York, 2017.
7. Jacek F. Gieras, Zbigniew J. Piech and Bronislaw Z. Tomczuk, “Linear Synchronous Motors:Transportation and Automation Systems,” Second Edition, CRC Press, Taylor & Francis Group,New York,2012
8. Toro. V. D, “Electric machines and power systems”, Prentice Hall of India, 1985.
9. Veinott, “Fractional horse power electric motors”, Mc Graw Hill, 1948

M. Tech. (Electrical), Semester – II (Elective – 3)

EEPE 116: ADVANCED POWER CONVERTERS FOR RENEWABLE APPLICATIONS

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Analyze and understand power converter interfaced solar PV systems
CO2	Select and design passive filters for grid-connected solar and wind systems
CO3	Analyze and understand converter topologies for solar PV systems
CO4	Analyze and understand converter topologies for wind turbine systems
CO5	Design and analyze converter control for solar and wind turbine systems

2. SYLLABUS

- **POWER CONVERTERS FOR SOLAR PV SYSTEMS** **(20 Hours)**

  PV system classifications, requirements, and challenges: Standalone, grid-feeding and hybrid PV systems, Grid-feeding inverters: central, string and micro-Inverters, single-stage and two-stage inverter configurations, Grid requirements for PV, DC and AC side filtering requirements and design, issue of leakage/residual current and remedial techniques, Control structure: MPPT and grid-current control.

  PV inverters derived from H-bridge topology: Basic full-bridge inverter, H5 inverter (SMA), HERIC inverter, REFU inverter, full-bridge inverter with DC Bypass (FB – DCBP), full-bridge Zero Voltage Rectifier (FB – ZVR)

  High Voltage-Gain DC-DC Converters: Magnetic coupling based isolated/non-isolated converters, voltage multiplier cell, switched inductor and switched capacitor based converters, voltage lift converters, Z-source and resonant converters

  PV Power Control: Grid Synchronization and PLL, MPPT & grid current control with above mentioned converters

- **POWER CONVERTERS FOR WIND TURBINE (WT) SYSTEMS** **(20 Hours)**

  WT system classifications and requirements: Power conversion structures for variable speed wind turbine systems with IG, DFIG and PMSM; Grid requirements for WT systems, Conventional unidirectional and bi-directional power converters for WT systems.

  Multilevel Power Converters: Three-Level Neutral-Point Diode Clamped Back-To-Back Topology (3L-NPC BTB), Three-Level H-Bridge Back-to-Back Topology (3L-HB BTB), Five-Level H-Bridge Back-to-Back Topology (5L-HB BTB), Three-Level Neutral-Point Diode Clamped Topology for Generator Side and Five-Level H-Bridge Topology for Grid Side (3L-NPC + 5L-HB).

  Introduction to Matrix Converters: Principle of operation, various configurations and applications.

- **MULTI-INPUT DC-DC CONVERTERS FOR RENEWABLE APPLICATIONS:** **(05 Hours)**

  Various multi-input DC-DC converter topologies, integration of PV, Wind and Fuel Cell sources.

Total Hours: 45

3. BOOKS RECOMMENDED:

1. Remus Teodorescu et al, ``Grid converters for photovoltaic and wind power systems'', John Willey & Sons Ltd., 2011.
2. Sudipta Chakraborty et al, ``Power Electronics for Renewable and Distributed Energy Systems: A Sourcebook of Topologies, Control and Integration'', Springer Science & Business, 2013.
3. Ashok L. Kumar et al,`` Power electronic converters for solar photovoltaic systems'', Academic Press, 2020.
4. Nicola Femi et al, ``Power Electronics and control for maximum Energy Harvesting in Photovoltaic Systems'', CRC Press, 2013.

M. Tech. (Electrical), Semester – I (Elective –3)

EEPE118: DISTRIBUTED POWER GENERATION AND MICRO-GRID

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain the basic principle of micro grid
CO2	Understanding of distributed energy resources
CO3	Analyse and control of Solar and wind Energy System
CO4	Analyse and control of Hybrid Energy System
CO5	Performance of the system with integration of real world problem
CO6	Economic aspect of micro grid

2. SYLLABUS

- **INTRODUCTION** **(08 Hours)**

  The basic concepts of power grid, Distributed power generation, the electric grid vs microgrids: technical and historic perspective, concept of microgrid, typical configuration of microgrid, AC and DC microgrids, interconnection of microgrids, technical and economical advantages of microgrid, challenges and disadvantages of microgrids, Islanding, need and benefits, different methods of islanding detection, modelling a microgrid system.

- **DISTRIBUTED ENERGY RESOURCES AND GENERATOR CONFIGURATION** **(10 Hours)**

  Introduction, Combined heat and power (CHP) systems, Solar photovoltaic (PV) systems, Wind energy conversion systems (WECS) , Small-scale hydro electric power generation, Storage devices: Batteries: Lead acid, nickel metal hydrate, and lithium ion batteries, ultra-capacitors, flywheels, Hydrogen energy storage Advantages and disadvantages of DG, Wind turbine, small hydro, diesel engine Driven Generators-squirrel-cage induction Generator, Synchronous Reluctance Generator, Permanent magnet Synchronous Generator, Doubly Fed Induction Generator and others, Control approach- voltage, frequency and power quality features, Generation of Power Using Geothermal Resources, Tidal and other sources.

- **SOLAR AND WIND ENERGY SYSTEM** **(08 Hours)**

  The solar energy conversion process, photovoltaic power conversion, power converters, photovoltaic characteristic, photovoltaic efficiency, design of photovoltaic system and control, MPPT, storage system based on a single cell battery, the energy yield of a photovoltaic module and the angle of incident, Wind power, selection of wind turbine, power flow analysis, power converters for single and three system, control approach for mitigation of power quality problem, isolated and grid connected system.

- **HYBRID ENERGY SYSTEM** **(10 Hours)**

  Diesel engine, Battery, wind turbine, small Hydro and PV based system- Configuration and various system combinations, Power Converters used for micro-grid applications, control approach for power quality, Configuration and control in isolated and grid connected system, AC and DC interconnection, Micro grid for rural area- overview, planning, specific characteristics.

- **PROTECTION ISSUES FOR MICROGRIDS** **(05 Hours)**

  Introduction, Islanding, Different islanding scenarios, Major protection issues of standalone Microgrid - Impact of DG integration on electricity market, environment, distribution system, communication.

- **INTRODUCTION TO SMART METERS** **(04 Hours)**

  Electricity tariff - one-part tariff, two tariff and maximum demand tariff - Dynamic pricing: Time of-use (TOU) pricing, critical-peak pricing (CPP) and Real Time, Pricing- Automatic Meter Reading (AMR).

Total Hours: 45

3. BOOKS RECOMMENDED:

1. Ali Keyhani Mohammad Marwali and Min Dai, “Integration of green and Renewable Energy in Electric Power Systems” John Wiley publishing company, New Jersey. 2010.
2. S. Chowdhury, S. P. Chowdhury, P. Crossley, “Microgrids and Active Distribution Networks”, IET Power Electronics Series, 2012
3. Ali Keyhani, Design of Smart Power Grid Renewable Energy Systems, ISBN: 978-0-470-62761-7, John Wiley and Sons, New Jersey, 2012
4. James Momoh, Smart Grid: Fundamentals of Design and Analysis, John Wiley & Sons, New Jersey,2012
5. R. C. Durgan, M. F. Me Granaghen, H. W. Beaty, “Electrical Power System Quality”, McGraw-Hill
6. Remus Teodorescu, Marco Liserre, Pedro Rodriguez, Grid Converters for Photovoltaic and Wind Power Systems, ISBN: 978-0-470-05751-3, Wiley
7. Qing Chang Zhong and Tomas Hornik, “ Control of power inverters in renewable energy and smart grid integration,” John Wilely& Sons, Limited, New Delhi, 2013.
8. William E. Glassley, “Geothermal Energy: Renewable energy and environment”, CRC Press, 2010
9. Rajeev kumar chauhan, Kalpana chauhan and Sri Niwas Singh, Microgrids for Rural Area: Reserach and case studies,The Institution of Engineering and Technology, London, United Kingdom, 2020
10. M. Rezkallah, A. Chandra, B. Singh and S. Singh, “Microgrid: Configurations, Control and Applications,” *IEEE Transactions on Smart Grid*, vol. 10, no. 2, pp. 1290-1302, March 2019.
11. S. Puchalapalli, S. K. Tiwari, B. Singh and P. K. Goel, “A Microgrid Based on Wind-Driven DFIG, DG, and Solar PV Array for Optimal Fuel Consumption,” *IEEE Transactions on Industry Applications*, vol. 56, no. 5, pp. 4689-4699, Sept.-Oct. 2020.

11.Topic related other Research papers from IEEE, IET and science direct etc

M. Tech. (Electrical), Semester – II (ELECTIVE-3)

EEPE 120: HVDC TRANSMISSION

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	explain the configurations, advantages and applications of HVDC Transmission
CO2	analyse the operation of HVDC converters
CO3	analyse HVDC control methods for power flow.
CO4	calculate the harmonics and filters parameters
CO5	analyse the Faults in HVDC System and their Protection
CO6	explain the Parallel Operation of AC-DC Systems

2. SYLLABUS

- **INTRODUCTION TO HVDC (06 Hours)**

  Historical development in DC Transmission, Advantages & Disadvantages of DC Transmission over Ac Transmission, DC Transmission Systems: Mono-polar, bi-polar and homo-polar lines, back-to-back HVDC systems, Components of HDVC Transmission System, classification, Main applications of DC Transmission

- **CONVERTER OPERATION (10 Hours)**

  Choice of converter configuration, 6-pulse and 12-pulse rectifiers and inverters; Equivalent circuits of rectifier and inverter, relations between ac and dc quantities.

- **CONVERTER CHARTS (03 Hours)**

  Charts with dc voltage and current as rectangular coordinates, charts with active and reactive powers as rectangular coordinates and their relation.

- **HVDC CONTROL SYSTEMS (06 Hours)**

  Constant current control, constant excitation angle control, VDCOL, constant ignition angle control, Individual phase control and equidistant pulse control; Valve blocking and by-passing; Starting, stopping and power flow reversal, advanced controller.

- **HARMONICS AND FILTERS (05 Hours)**

  Characteristic and non-characteristic harmonics, input harmonics, output harmonics, problems due to harmonics, ac and dc filters.

- **FAULTS IN HVDC SYSTEM AND THEIR PROTECTION (05 Hours)**

  DC line faults, clearing line faults, converter faults, ac system faults, rectifier side and inverter side faults; DC circuit breakers, overvoltage protection.

- **PARALLEL OPERATION OF AC-DC SYSTEMS (04 Hours)**

  Influence of ac system strength on ac-dc interaction, effective short-circuit ratio (ESCR), problems with low ESCR systems

- **RECENT DEVELOPMENTS IN HVDC TRANSMISSION** **(06 Hours)**

  Problems encountered with classical (CSC based) HDVC Transmission Systems and their overcome by VSC based HVDC systems, Operation Principle and control of VSC Based HVDC Transmission, VSC-HVDC Under AC and DC Fault Conditions, HVDC light.

Total Hours: 45

3. BOOKS RECOMMENDED:

1. E. Kimbark, Direct Current Transmission by Wiley International New York, 1971.
2. K.R. Padiyar, HVDC Power Transmission System, New Age International Private Limited, 2008.
3. E.Ulmann, Power Transmission by Direct Current, Springer-Verlag, 1975
4. P. Kundur, Power System stability and control, Tata McGraw Hill education, 1994.
5. J. Arrillaga, High Voltage Direct Current Transmission, IEE Power Engineering series, London, 1998
6. J. Arrillaga, Y. H. Liu and N. R. Watson, Flexible Power Transmission: The HVDC Option, John Wiley and Sons, New York, 2007.
7. Nagwa F. Ibrahim and Sobhy S. Dessouky,Design and Implementation of Voltage Source Converters in HVDC Systems, Springer Nature, Switzerland, 2021.
8. Chan-Ki Kim,Vijay K. Sood,Gil-Soo Jang,Seong-Joo Lim and Seok-Jin Lee, HVDC Transmission Power Conversion Applications in Power Systems, John Wiley & Sons, Singapore, 2009.

M. Tech. (Electrical), Semester – II (Elective – 3)

EEPE 122: CONDITION MONITORING & FAULT DIAGNOSIS OF ELECTRICAL MACHINES

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	explain the basic understanding of condition monitoring
CO2	modeled and analyze electrical machines
CO3	analyze performance of fault diagnostics methods
CO4	analyze the performance using soft computing method
CO5	Implementation and Performance of the techniques in real world problem

2. SYLLABUS

- **CONDITION MONITORING** **(08 Hours)**

  Needs, offline and online monitoring, type of faults-stator, rotor, Bearing, broken rotor faults, eccentricity faults, Insulation ageing mechanisms, Insulation failure modes, Failures in electrical machines, Thermal Monitoring of the Induction Machine, Instrumentation requirements.

- **MODELING OF ELECTRICAL MACHINES** **(08 Hours)**

  Introduction, winding and modified approach, validation of inductance calculation, indirect application of magnetic equivalent circuit analysis of synchronous and induction motors, direct approach of magnetic equivalent circuit, Methodology for monitoring the induction machine.

- **FAULT DIAGNOSTICS METHODS** **(11 Hours)**

  Fault Diagnostics using FEM, impact of magnetic saturation on accurate fault detection, analysis of air gap, vibration, noise, frequency domain method-detection of motor bearing faults, stator faults, rotor faults, eccentricity faults, fault diagnosis using model based approach in induction motor and others motors, Closed-Loop Diagnosis of the Induction Machine, Induction Machine Diagnosis Using Observers, Signal processing techniques for signal analysis.

- **FAULT DIAGNOSIS USING SOFT COMPUTING METHODS** **(10 Hours)**

  Fault Diagnosis using artificial neural networks-Methodology, detection problem, Signature of the stator and rotor faults, Diagnosis, Application of Fuzzy logic and other soft computing techniques.

- **IMPLEMENTATION OF FAULT DIAGNOSIS METHOD** **(08 Hours)**

  Introduction, on board fault diagnosis in electric vehicles, Fault diagnostic techniques applied to voltage source inverter-fed drives, DC–DC converters: Signal-processing-based algorithms and other systems, Wavelet transform.

Total Hours: 45

3. BOOKS RECOMMENDED:

1. Hamid A. Toliyat, Subhasis Nandi,Seungdeog Choi, Homayoun Meshgin-Kelk, Electric Machines: Modeling, Condition Monitoring, and Fault Diagnosis, CRC Press, Boca Raton, 2018.
2. Peter J. Tavner, Li Ran, Jim Penman, Howard Sedding “Condition Monitoring of Rotating Electrical Machines”, The Institution of Engineering and Technology, London, 2008.
3. Antonio J. Marques Cardoso, Diagnosis and Fault Tolerance of Electrical Machines, Power Electronics and Drives,The Institution of Engineering and Technology(IET), London.2018.
4. Elias G. Strangas, Guy Clerc, Hubert Razik and Abdenour Soualhi, “Fault Diagnosis, Prognosis, and Reliability for Electrical Machines and Drives,” John Wiley & Sons, New Jersey,2022.
5. Jean-Claude Trigeassou, Electrical Machines Diagnosis, John Wiley & Sons, Inc, (Great Britain and the United States by ISTE Ltd), 2011

M. Tech. (Electrical), Semester – II (Elective-3)

EEPE124: DIGITAL CONTROL OF POWER CONVERTERS

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	understand the features of 32-bit controllers
CO2	understand the fundamentals of different architectures of 32-bit microcontrollers
CO3	design programs for the 32 -bit processor using embedded C
CO4	implement algorithms on processor for power electronic converter and drives
CO5	

2. SYLLABUS

- **INTRODUCTION TO 32-BIT CONTROLLERS AND EMBEDDED 'C' PROGRAMMING (06 Hours)**

  Introduction, RISC and CISC architecture, Harvard and Von Neumann architecture, comparison of RISC based microcontrollers, Features of 32-bit architecture, addressing modes, instruction set, and Development tools. Variables and constants, storage classes, enumerations and definitions, I/O operations, control statements, functions, pointers and arrays, structure and unions, interrupt service routines.

- **STM-32 ARCHITECTURE & PROGRAMMING (12 Hours)**

  ARM Cortex M core, bus matrix, AHB and APB buses, different clock domains on MCU, Architecture, introduction to STM32CUBE MX and Programming of peripherals like GPIO, Timers, PWM Timers, UART, DAC, ADC, SPI, I2C using Embedded 'C', Hardware debugging techniques.

- **C2000 ARCHITECTURE & PROGRAMMING (14 Hours)**

  Architecture of C2000 DSP's, Instruction sets in C2000, Introduction to code composer studio (CCS) and Programming of peripherals like GPIO, UART, DAC, ADC, SPI, I2C using Embedded 'C', Hardware debugging techniques.

- **APPLICATIONS (13 Hours)**

  Understanding digital control of DC-DC converters, Generation of sine wave and viewing in DAC, control of Induction motor, PMSM, BLDC. Example programs for communication interfaces like I2C interface, RS232 interface, understanding the encoder features in C2000 for drive application.

Total Hours: 45

3. LIST OF EXPERIMENTS

1. Arithmetic operations of Signed and Unsigned Numbers
2. Memory Block Movements (Forward, reverse, overlapping)
3. Ascending and descending arrangement of data string.
4. Code conversion. (Hexadecimal, BCD, Binary, ASCII etc.)
5. Toggling of port pin with time delay.
6. Sensing of push button keys.
7. Generate different duty cycle and different switching frequency waveform using timers.
8. Generate sine wave and triangular wave using DAC
9. Measure voltage and current using ADC

4. BOOKS RECOMMENDED:

1. Trevor Martin, "The Insider's Guide to The STM 32", Published by Hitex (UK) Ltd., April 2005.
2. Joseph, Yiu, "The Definite Guide to cortex –M3/M4", Elsevier publication, 2007.
3. Datasheet and user manual of STM F4 series MCU, www.st.com.
4. Datasheet and user manual of TI digital signal controllers.

M. Tech. (Electrical), Semester – II (Elective – 4)

EEPE 132: ADVANCED ENERGY STORAGE DEVICES AND APPLICATIONS

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Describe different energy storage technology and compare them based on their performance
CO2	Modelling of various electrochemical storage devices and develop suitable battery management system
CO3	Discuss electrical and magnetic storage systems and describe hydrogen and fuel cells
CO4	Detailed understanding of thermal and mechanical storage and analyze energy savings
CO5	Explain and illustrate hydrogen and fuel cells

2. SYLLABUS

- **INTRODUCTION TO ENERGY STORAGE** **(05 Hours)**

  Relevance and scenario, perspective on development of energy storage systems, energy storage criteria, general concepts, fundamentals and applications, energy storage technologies, future prospect of storage, Ragone plots,.

- **ELECTROCHEMICAL ENERGY STORAGE** **(10 Hours)**

  Battery technologies and different battery chemistry, electrode materials, electrolytes. performance comparison, reaction mechanism, practical parameters, technical characteristics, equivalent circuit. Testing, standards and system sizing, battery storage integration.

- **BATTERY MANAGEMENT SYSTEM (BMS)** **(10 Hours)**

  BMS functionality, requirements; State Estimation: definitions and their estimation methods; SOH estimation: predictive SOH models, aging, capacity estimation, self-discharge detection, parameter estimation, remaining useful life estimation; Cell balancing: causes of imbalancing, balancing strategies, charge transfer balancing-design choices, circuits for balancing; thermal management of battery; case study

- **ELECTRICAL AND MAGNETIC STORAGE SYSTEMS** **(08 Hours)**

  Supercapacitors: basics, technical characteristics, equivalent circuit, electrode material, pseudocapacitive energy storage, energy storage devices, applications and challenges; Magnetic Systems- energy storage in superconducting magnetic systems, superconductive materials, applications.

- **FUEL CELLS AND HYDROGEN STORAGE** **(06 Hours)**

  Fuel cell: working, basic components, principle, thermodynamics of fuel cell, types, challenges; Hydrogen storage-hydrogen as an energy vector and basic principles, hydrogen production, strategies for storing energy in hydrogen, applications.

- **THERMAL AND MECHANICAL STORAGE** **(06 Hours)**

  Basic principle, criteria for TES evaluation, operating characteristics, standards, phase change materials, sensible TES-passive and active systems, design and thermal stratification, energy and exergy analyses, efficiency measures. Mechanical storage: flywheel, pumped hydropower storage and compressed-air energy storage, comparison and application, principle of operation, function and deployments; case study

Total Hours: 45

3. BOOKS RECOMMENDED:

1. Robert A. Huggins, “Energy storage”, Springer Nature, 2nd edition, 2016.
2. Christopher D. Rahn, and Chao-Yang Wang, “Battery systems engineering”, John Wiley & Sons, 2013.
3. Ibrahim Dincer, and Marc A. Rosen, “Thermal energy storage: systems and applications” John Wiley & Sons, 3rd edition, 2021.
4. Gregory L. Plett, “Battery management systems, Volume II: Equivalent-circuit methods”, Artech House, 2015.
5. Phil Weicker, “A systems approach to lithium-ion battery management”, Artech house, 2013.
6. F. Barnes and J. Levine. "Large energy storage systems", CRC press, 2011.

M. Tech. (Electrical), Semester – II (Elective – 4)

EEPE 134: INSTRUMENTATION FOR DRIVES

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	understand the basic signal conditioning for measurement of electrical quantities.
CO2	study and implement different transducers for electrical motor drives.
CO3	design the digital measurement techniques for motor drives.
CO4	understand the EMI and EMC
CO5	study the protection method for electrical motor drives

2. SYLLABUS

- **TRANSDUCERS FOR DRIVES** **(11 Hours)**

  Current, voltage, speed: incremental and absolute encoders, revolvers, torque sensors

- **DIGITAL MEASUREMENT TECHNIQUES FOR DRIVES** **(12 Hours)**

  Digital techniques of measurement of voltage, current, power, energy, speed and position and direction of rotation

- **SIGNAL CONDITIONING, DATA ACQUISITION AND CONVERSION** **(11 Hours)**

  Instrumentation amplifiers, isolation amplifiers, opto-couplers, sample and hold circuits, V/f and f/V converters, A/D and D/A converters, data acquisition systems

- **EMI AND EMC** **(11 Hours)**

  Introduction, causes of EMI, interference coupling mechanism, basics of circuit layout and grounding, concepts of interfaces, filtering and shielding. Safety: Introduction, electrical hazards, hazardous areas and classification, non-hazardous areas, enclosures – NEMA types, fuses and circuit breakers. Protection methods: Purging, explosion proofing and intrinsic safety

Total Hours: 45

3. BOOKS RECOMMENDED:

1. Helfrick – Cooper, Modern electric instrumentation and measurement technique, PHI 1994.
2. T.S. Rathore, Digital measurement techniques, Narosa publishing House, 1996.
3. Rangan, Sanna, mani, Instrumentation devices & systems, TMH 1997.
4. Golding and Widdis, “Electrical measurements & Measuring instruments”, Wheeler books, 5th edition
5. Doebelin E.O, “Measurement Systems - Application and Design”, Fourth edition, McGraw-Hill, New York, 1992.

M. Tech. (Electrical), Semester – II (Elective – 4)

EEPE 136: APPLICATION OF POWER ELECTRONICS TO POWER SYSTEM

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain synchronous reference theory, instantaneous reactive power theory and voltage source inverter
CO2	Designing PLL for grid-synchronization
CO3	Explain basics of reactive power compensation
CO4	Analyze and understand various static shunt compensators
CO5	Analyze and understand various static series compensators

2. SYLLABUS

- **INTRODUCTION** **(01 Hours)**

  Voltage source inverter (VSI), Synchronous reference frame theory, Instantaneous reactive power theory, PLL for grid synchronization

- **BASICS OF REACTIVE POWER COMPENSATION** **(09 Hours)**

  Analysis of uncompensated AC line, Passive reactive power compensation, Compensation by a series capacitor connected at the mid-point of the line, Effect on Power Transfer capacity, Compensation by STATCOM and SSSC, Synchronous condenser

- **STATIC VAR COMPENSATORS** **(11 Hours)**

  Configuration of SVC, Thyristor-controlled reactor (TCR), Fixed capacitor-Thyristor controlled reactor (FC-TCR), Thyristor switched capacitor (TSC), Thyristor-switched capacitor-thyristor controlled reactor (TSC-TCR), Advantages of the slope in the SVC Dynamic Characteristic, Influence of the SVC on System Voltage, Design of the SVC Voltage Regulator.

- **STATIC SYNCHRONOUS COMPENSATOR (STATCOM)** **(5 Hours)**

  Principle of operation, Analysis of a three phases six pulse STATCOM, Multi-pulse converters, Applications of STATCOM.

- **THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC) AND STATIC SYNCHRONOUS SERIES COMPENSATOR (SSSC)** **(08 Hours)**

  Principle of operation, Analysis and control, Applications.

- **UNIFIED POWER FLOW CONTROLLER (UPFC)** **(06 Hours)**

  Principle of operation, Analysis and control, Applications

Total Hours: 45

3. BOOKS RECOMMENDED:

1. Mathur R. Mohan & Varma R. K., `` Thyristor based FACTS controller for electrical transmission system'', Wiley Inter-Science, 2002.
2. Padiyar K. R., `` FACTS Controller in power transmission and distribution'', New Age International, 1st edition 2007.
3. N.G. Hingorani, `` Understanding FACTS'', IEEE Press 2001.
4. Vijay K. Sood, "HVDC and FACTS Controllers: Applications of Static Converters in Power Systems", Springer; 1 edition, 2004.
5. T.J.E. Miler, ``Reactive Power Control in Electric Systems'', John Wiley & Sons, 1982.

M. Tech. (Electrical), Semester – II (Elective – 4)

EEPE 138: MODEL PREDICTIVE CONTROL FOR POWER ELECTRONICS APPLICATIONS

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	understand model predictive control
CO2	apply model predictive control to DC-DC converters and three-phase voltage source converters
CO3	understand working of modular multilevel converters (MMCs) and apply model predictive control to MMCs
CO4	apply model predictive control technique for variable frequency drives.
CO5	understand working of wind energy conversion system (WECS) and apply model predictive control to WECS

2. SYLLABUS

- **REVIEW OF CLASSICAL CONTROL AND INTRODUCTION TO MODEL PREDICTIVE CONTROL (08 Hours)**

  Power electronic converters in energy conversion, control and modulation schemes, classical current control, voltage-oriented control, direct control, fuzzy Logic control, sliding mode control, introduction to model predictive control, classification of model predictive control, main features of finite control set model predictive control, challenges of finite control set model predictive control, comparison of classical control and model predictive control.

- **MODEL PREDICTIVE CONTROL OF DC/DC CONVERTER (05 Hours)**

  Model predictive control of buck converter, model predictive control of boost converter, model predictive control of buck-boost converter, model predictive control of isolated dual active bridge dc/dc converter.

- **MODEL PREDICTIVE CONTROL OF A TWO-LEVEL THREE-PHASE INVERTER (05Hours)**

  Model predictive control of three-phase inverter in grid connected and islanded modes, control techniques using constant and variable switching frequency model predictive control.

- **MODEL PREDICTIVE CONTROL OF MODULAR MULTILEVEL CONVERTERS (07 Hours)**

  Introduction to modular multilevel Converters (MMCs), classical control of MMCs, direct model predictive control, and indirect model predictive control of MMCs.

- **MODEL PREDICTIVE CONTROL OF MOTOR DRIVES (10 Hours)**

  Introduction to motor drives, dynamic model of an induction machine, model predictive torque control of an induction machine fed by a voltage source inverter, field-oriented control of an induction machine fed by a matrix converter using model predictive current control, permanent magnet synchronous machine equations, discrete-time model of permanent magnet synchronous machine, field-oriented control using model predictive current control of permanent magnet synchronous machine.

- **MODEL PREDICTIVE CONTROL OF WIND ENERGY CONVERSION SYSTEM (10 Hours)**

  Model predictive control of DFIG WECS with voltage source converters, model predictive control of PMSG WECS with back-to-back connected converter, model predictive control of PMSG WECS with passive generator-side converters.

Total Hours: 45

3. **BOOKS RECOMMENDED:**

1. Jiefeng Hu, Josep Guerrero and Syed Isla, "Model Predictive Control for Microgrids-From power electronic converters to energy management", The Institution of Engineering and Technology, 1st edition 2021.
2. Jose Rodriguez and Patricio Cortes, "Predictive Control of Power Converters and Electrical Drives", John Wiley & Sons Ltd , 1st edition 2012.
3. Tobias Geyer, "Model Predictive Control of High Power Converters and Industrial Drives", Wiley, 1st edition 2017.
4. Venkata Yaramasu and Bin Wu, "Model Predictive Control of Wind Energy conversion Systems" John Wiley & Sons Ltd , 1st edition 2017.

M. Tech. (Electrical), Semester – II (Elective – 4)

EEPE 140: ELECTRICAL MACHINES FOR RENEWABLE ENERGY GENERATION

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain the fundamental issues and challenges of harvesting Renewable energy
CO2	Analyze the different forms of energy storage by renewable energy sources
CO3	Explain principle and construction, characteristics of electrical machines promising for renewable energy
CO4	Compare existing machines and advanced renewable energy machines
CO5	Identify the design modification of machines for renewable energy
CO6	Select the appropriate electrical machines for harnessing renewable energy

2. SYLLABUS

- **FORMS OF ENERGY STORAGE BY RENEWABLE ENERGY SOURCES (03 Hours)**

  Kinetic energy, Potential Energy, Heat energy.

- **CLASSIFICATION OF ELECTRIC MACHINES (05 Hours)**

  Existing machines – wound filed DC, PMDC, induction machines (wound rotor, DFIG, cage rotor), synchronous machines: wound rotor, PMSG, PM BLDC, PM BLAC, surface mounted PM, surface inset PM, interior radial PM, interior circumferential PM, Advanced machines - stator PM: DSPM (doubly salient), FRPM (flux reversal), FCPM (flux controllable, single magnet, dual magnet DSPM, Direct drive PM machine, Vernier PM machine, Linear Direct drive PM machine, Magnet less machines – switched reluctance machines, doubly salient magnet less machines

- **EXISTING MACHINES FOR RENEWABLE ENERGY (17 Hours)**

  Classifications Principle, construction and characteristics of Synchronous Generator, Induction Generator, Doubly Fed Induction Generator, Permanent Magnet Synchronous Generator, Linear Permanent Magnet Synchronous Generator.

- **ADVANCED RENEWABLE ENERGY MACHINES (20 Hours)**

  Classifications, Principle, construction characteristics and Application of Stator-PM Machines. Direct-drive PM Machines and Magnet less Machines

Total Hours: 45

3. BOOKS RECOMMENDED:

1. K.T. Chau .Electric Machines and Drives for Renewable Energy Harvesting, Energies, special issues, MDPI, 2017
2. D.P. Kotahri, K.C. Singal, Rakesh RanjanRenewable Energy sources and emerging technologies , PHI, 2009
3. Pyrhonen, J.; Jokinen, T.; Hrabovcova, V. Design of Rotating Electrical Machines; Wiley: Chichester, UK, 2007.
4. D.S. Chauhan, S. K. Srivatava, Non- Conventional Energy Resources, New Age international Publishers, Third edition,2014
5. Selected Journal papers on Advanced Electrical machines for Renewable Energy.

M. Tech. (Electrical), Semester – II (Elective – 4)

EEPE 142: FPGA BASED CONTROL OF POWER ELECTRONIC CONVERTERS

L	T	P	C
3	0	0	3

1. **COURSE OUTCOMES (COs)**

At the end of this course the students will be able to

CO1	write programs using Verilog HDL code.
CO2	simulate the programs using integrated development environment (IDE).
CO3	interface the FPGA with external hardware using ADC/DAC and GPIO port.
CO4	generate gate pulses to control various power electronic converters.
CO5	develop a laboratory prototype of FPGA based controller for PE converters.

2. **SYLLABUS**

- **Introduction** **(05 Hours)**
  Review of digital logic circuits, Different kinds of programmable logic devices: Field Programmable Gate Array (FPGA), Programmable Logic Device (PLD), FPGA manufacturers (Xilinx, Altera, Actel, Lattice Semiconductor, Atmel). FPGA applications. Adjoining devices. Instruments and software.

- **The Structure of FPGA** **(**05 Hours)
  FPGA general description. Different kinds of FPGA packages. FPGA architecture. Internal hard modules of FPGA (CLB, Block RAM, DCM), their meanings and usage. Different kinds of I/O modules, their usage and configuration

- **Hardware Description Language** (15 hours)
  Introduction to Verilog HDL, Overview of Digital Design with Verilog HDL, Hierarchical Modeling Concepts, Basic Concepts, Modules and Ports, Gate-Level Modeling, Dataflow Modeling, Behavioural Modeling, Tasks and Functions, Useful Modeling Techniques, Timing and Delays, Switch-Level Modeling, User-Defined Primitives, Programming Language Interface, Logic Synthesis with Verilog HDL

- **FPGA Design Flow** (10 Hours)
  Architecture design, Project design using Verilog Hardware Description Language (HDL), Defining testing methodology and test bench design, RTL simulation, synthesizing, implementation, gate level simulation of design, Reusing of internal hard modules during design and implementation.

- **FPGA Configuration and Testing Methodology** (10 Hours)
  Introduction to integrated development environment (IDE) for system Verilog, Different types of FPGA configuration files, Generation of configuration file and its loading into FPGA. Functional and gate level testing. SDF file description and usage.

Assignments:

Sl. No.	Name of the Assignment
1.	Getting acquainted with Verilog programming (i) Full adder, (ii) Up-down counter (iii) LED blink (iv) LCD display
2.	Interfacing using GPIO pins
3.	Generation of Arbitrary waveforms using Look up table (LUT)
4.	ADC/DAC interfacing
5.	Open-loop control of DC-DC converters (i) Buck (ii) Boost (iii) Buck-boost
6.	Square wave operation of Single-phase inverter (i) Half- Bridge with R and R-L load (ii) Full- Bridge with R and R-L load
7.	Single phase AC voltage controller with R and R-L load
8.	Operation of three phase inverter in 120° and 180° conduction modes
9.	Generation of gating pulses using Sine PWM technique
10.	Transformation from 3-phase to 2-phase and arbitrarily rotating reference frame

3. **BOOKS RECOMMENDED:**

1. Samir Palnitkar, "Verilog HDL - A guide to Digital Design and Synthesis", SunSoft Press 1996.
2. P. Chu Pong, "FPGA Prototyping by Verilog Examples", Xilinx Spartan, 3rd version, 2008
3. DE1-SoC Getting started Guide for ALTERA Cyclone V GX, " https://www.terasic.com.tw/cgi-bin/page/archive.pl?Language=English&CategoryNo=165&No=836&PartNo=4#contents"
4. NPTEL video Lectures on "Hardware modelling using Verilog by Prof. Indaranil Sengupta, IIT Kharagpur".

M. Tech. (Electrical), Semester – II (Institute Elective – 1)

EEPE 172: ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain the fundamental issues and challenges of Artificial Intelligence
CO2	Analyze various Machine learning algorithms
CO3	Compare machine learning/artificial intelligence approaches
CO4	Apply various Machine learning methods
CO5	Develop ANN/FL algorithms and models
CO6	Implement various machine learning algorithms in real-world applications

2. SYLLABUS

- **INTRODUCTION TO MACHINE LEARNING (ML) (08 Hours)**

  Identification in the Limit, Oracle Based Learning, Probably Approximately Correct (PAC) Model, Boosting Bayesian Learning: Maximum Likelihood, Estimates, Parameter Estimation. Types of Machine learning – Basic Concepts in Machine Learning - SUPERVISED LEARNING: Linear Models for Classification: Discriminant Functions - Probabilistic Generative Models - Probabilistic Discriminative Models - Bayesian Logistic Regression, linear models, Logistic Regression, Generalized Linear Models, Unsupervised learning, clustering: K-means/Kernel K-means, Dimensionality, Reduction: PCA and kernel PCA, Evaluating Machine Learning algorithms and Model Selection, Ensemble Methods (Boosting, Bagging, Random Forests), Modelling Sequence /Time- Series Data, Deep Learning and Feature Representation, Learning, Scalable Machine Learning (Online and Distributed Learning)

- **INTRODUCTION TO ARTIFICIAL INTELLIGENCE (AI): (08 Hours)**

  Computerized reasoning – Artificial Intelligence (AI) – characteristics of an AI problem – Problem representation in AI – State space representation – problem reduction, Concept of small talk programming, Knowledge representation issues, predicate logic- logic programming, semantic nets- frames and
  inheritance, constraint propagation, representing knowledge using rules, rules based deduction systems, Reasoning under uncertainty, review of probability, Baye's probabilistic interferences and Dempster Shafer theory.

- **ARTIFICIAL NEURAL NETWORKS (ANN) (11 Hours)**

  Feed forward Network Functions - Error Backpropagation -Regularization in Neural Networks – Mixture Density Networks – Bayesian Neural Networks. Kernel Methods – Dual Representations – Radial Basis Function Networks – Ensemble learning: Boosting – Bagging. Forecasting models using ANN, Trend analysis, Cyclical and Seasonal analysis, smoothing; Moving averages; Box-Jenkins, Holt-winters, Auto-correlation; ARIMA, Examples: Applications of Time Series in financial markets

- **FUZZY LOGIC (10 Hours)**

  Reasoning in uncertain environments, Fuzzy logic, fuzzy composition relation, operations on fuzzy sets, fuzzification - defuzzification, fuzzy decision making, fuzzy logic controllers, Fuzzy Classification: Classification by equivalence relations-crisp relations, Fuzzy relations, Cluster analysis, Cluster validity, C-Means clustering, Hard C-Means clustering, Fuzzy C-Means algorithm, Classification metric, Hardening the Fuzzy C-Partition.

- **APPLICATION** **(08 Hours)**

  Examples of Machine Learning Applications – Linear Models for Regression – Linear Basis Function Models – The Bias-Variance Decomposition – Bayesian Linear Regression – Bayesian Model Comparison. Radar for target detection, Deep Learning Automated ECG Noise Detection and Classification, ML in Network for routing, traffic prediction and classification, Application of ML in Cognitive Radio Network (CRN).

Total Hours: 45

3. BOOKS RECOMMENDED:

1. Timothy J.Ross - Fuzzy logic with engineering applications, 3rd edition, Wiley, 2010.
2. George J.KlirBo Yuan - Fuzzy sets and Fuzzy logic theory and Applications, PHI, New Delhi,1995
3. Applied Machine Learning, M. Gopal, McGraw Hill Education
4. Machine Learning March 1997, Thomas M. Mitchell, McGraw-Hill, Inc. 2. Neural Networks: A Comprehensive Foundation, Simon Haykin, Prentice Hall
5. Neural Network Design, M. T. Hagan, H. B. Demuth, Mark Beale, Thomson Learning, Vikash Publishing House
6. Patrick Henry Winston, “Artificial Intelligence”, Addison Wesley, 2000.
7. Luger George F and Stubblefield William A, “Artificial Intelligence: Structures and Strategies for Complex Problem Solving”, Pearson Education, 2002.
8. Christopher Bishop, “Pattern Recognition and Machine Learning” Springer, 2007.
9. Kevin P. Murphy, “Machine Learning: A Probabilistic Perspective”, MIT Press, 2012.
10. Ethem Alpaydin, “Introduction to Machine Learning”, MIT Press, 3rd Edition, 2014
11. Sayed, A.H., 2014. Adaptation, learning, and optimization over networks. Foundations and Trends” in Machine Learning, 7(4-5), pp.311-801.

M. Tech. (Electrical), Semester – II (Institute Elective – 1)

EEPE 174: MODERN INDUSTRIAL DRIVES AND AUTOMATION

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Understand the modern industry drive and its installation and connections
CO2	Apply the various parameter setting
CO3	Explain the need of industrial automations
CO4	Develop the ladder logic for various industrial applications
CO5	Design the scheme to operate dive with PLC

2. SYLLABUS

- **MODERN INDUSTRIAL DRIVES (23 Hours)**

  Introduction, Applications of modern industrial drive, specification of Modern Industrial Drives, Installation, connections- control and power terminals, commissioning, parameter setting, open loop and close loop speed control, change of acceleration and de-acceleration time, over speeding, forward/reverse operating with operating two drive in synchronism, sensorless speed control, speed control with encoder, use of digital inputs and outputs of drive.

- **INDUSTRIAL AUTOMATION (22 Hours)**

  Need for an industrial automation, PLC definition, overview of PLC systems, input/output modules, power supplies and isolations. General PLC programming procedures, programming on-off inputs/ outputs, Bit logic, data move, timers, counters, compare, convert instructions. Arithmetic instructions. Analog value processing. Generation of Analog output to control drive, control of drive with digital output of PLC. Speed variation of industrial drive with digital and analog output of PLC.

Total Hours: 45

3. BOOKS RECOMMENDED:

1. G.K.Dubey, Fundamentals of Electrical Drives, Narosa- 1995.
2. S.A. Nasar, Boldea, Electrical Drives, Second Edition, CRC Press – 2006.
3. M. A. ElSharkawi, Fundamentals of Electrical Drives, Thomson Learning -2000.
4. John W. Webb and Ronald A. Reis, Programmable Logic Controllers - Principles and Applications, Fourth edition, Prentice Hall Inc., New Jersey, 1998.
5. Frank D. Petruzella, Programmable Logic Controllers, Second edition, McGraw Hill, New York, 1997.

M. Tech. (Electrical), Semester – II (Institute Elective – 1)

EEPE 176: ADVANCED OPTIMIZATION METHODS

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain the basic principle of optimization
CO2	Derive the equations and solution through linear programming Method
CO3	Estimate the performance of traditional optimization method
CO4	Analyse the performance of constrained optimization algorithms
CO5	Analyse the Induction of Non-traditional Optimization algorithms.
CO6	Apply the optimization method in real world.

2. SYLLABUS

- **INTRODUCTION** **(06 Hours)**

  Historical Development, Engineering application of Optimization, Formulation of design problems, objective function, design constraints, Classification of optimization problems, local and global maximum and minima, classical optimization methods.

- **LINEAR PROGRAMMING** **(08 Hours)**

  Standard form, Geometry of LP problems, Theorem of Linear programming problems and Relation to convexity, Pivot reduction method, Simplex method, Revised simplex method, Duality in linear programming(LP), Sensitivity analysis, Karmarkar's method, other algorithms for solving LP problems.

- **SINGLE AND MULTI VARIABLE OPTIMIZATION** **(08 Hours)**

  Single variable: Optimality criteria, Bracketing Methods, Region Elimination Method, Gradient Based methods: Newton-Raphson Method, Bisection Method, Secant Method, Multivariable: Optimality criteria, Direct Search Methods, Gradient Based Methods: Steepest Descent Method, Conjugate Gradient Method, Quasi-Newton Method, Variable Metric Method, applications.

- **CONSTRAINED OPTIMIZATION TECHNIQUES** **(07 Hours)**

  Characteristics of a constrained problem, Variable Elimination Method, Lagrange Multiplier, Kuhn-Tucker Conditions, Frank-Wolfe Method, Cutting plane Method, penalty function Methods, application.

- **ADVANCED OPTIMIZATION TECHNIQUES** **(16 Hours)**

  Introduction to Multi objective Optimization: classical method-weighted sum method, ε-constrained method, Benson's method, Genetic Algorithm, Evolution strategies, multi model function, constrained based problems, Swarm intelligences, Teaching Learning Based Optimization, Rao algorithms and other Non-traditional Optimization Algorithms, applications.

Total Hours: 45

3. BOOKS RECOMMENDED:

1. S. S. Rao, 'Engineering "Optimization theory and applications", Fourth Edition, John Wiley and Sons, 2009.
2. Kalyanmoy Deb, "Optimization for Engineering Design: Algorithms and Examples" Prentice-Hall of India Pvt.Ltd.,2005.
3. M.S. Bazaraa, H.D. Sheraliand C. Shetty, "Nonlinear Programming, Theory and Algorithms", John Wiley and Sons, New York, 1993.
4. Ke-Lin Du and M.N.S. Swamy, "Search and Optimization by Metaheuristics Techniques and Algorithms Inspired by Nature," Springer International Publishing Switzerland, 2016.

5. R. Venkata Rao, Teaching Learning Based Optimization Algorithm and Its Engineering Applications, Springer International Publishing Switzerland, 2016.
6. Kwang Y. Lee and Mohamed and A. El-Sharkawi, Modern Heuristic Optimization Techniques Theory And Applications To Power Systems, John Wiley & Sons, Inc., Hoboken, New Jersey, 2008.
7. Gang Lei, Jianguo Zhu and Youguang Guo, "Multidisciplinary Design Optimization Methods for Electrical Machines and Drive Systems," Springer-Verlag Berlin Heidelberg 2016.
8. Rangrajan K. Sundaram,"A First Course in Optimization Theory", Cambridge UniversityPress,1996
9. A.Ravindran, K.M. Ragsdell, G.V.Reklaitis," Engineering Optimization Methods and Applications', Wiley India Pvt.Ltd., 2006.
10. E.S. Gopi, "Algorithm Collections for Digital Signal Processing Applications Using MATLAB," Springer, Dordrecht, The Netherlands,2007

M. Tech. (Electrical), Semester – II (Institute Elective – 1)

EEPE 178: SMART GRID TECHNOLOGY

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	To explain the basic understanding of smart grid
CO2	To explain integration of renewable energy with smart grid
CO3	To analyze communication performance of smart grid
CO4	To analyze the performance of design system
CO5	To analyze stability of the system
CO6	To explain quality of the developed system

2. SYLLABUS

- **SMART GRID ARCHITECTURAL DESIGNS** **(08 Hours)**

  Today's Grid versus the Smart, General View of the Smart Grid Market Drivers, Stakeholder Roles and Function, Utilities, Working Definition of the Smart Grid Based on Performance Measures, Functions of Smart Grid Components, Smart Devices Interface Component, Storage Component, Monitoring and Control Technology Component , Demand Side Management Component.

- **RENEWABLE ENERGY SYSTEM AND STORAGE** **(08 Hours)**

  Sustainable Energy Options for the Smart Grid- solar power, wind system, biomass, small hydropower system, Geothermal, Tidal energy, Environmental Implications, Electric Vehicles and Plug-in Hybrids, Opportunities and Challenges, Application of smart system, Demand response issues, Storage technologies.

- **SMART GRID COMMUNICATIONS AND MEASUREMENT TECHNOLOGY** **(07 Hours)**

  Monitoring, PMU, Smart Meters, and Measurements Technologies, Wide Area Monitoring Systems (WAMS), Phasor Measurement Units (PMU), Smart Meters, Smart Appliances, Advanced Metering Infrastructure (AMI), Multiagent Systems (MAS) Technology, Multiagent Systems for Smart Grid Implementation.

- **PERFORMANCE ANALYSIS TOOLS FOR SMART GRID DESIGN** **(08 Hours)**

  Introduction to Load Flow Studies, Challenges to Load Flow in Smart Grid and Weaknesses of the present Load Flow Methods, Load Flow State of the Art: Classical, Extended Formulations, and Algorithms, Distribution Load Flow Methods, Congestion Management Effect, Load Flow for Smart Grid Design, the Development of Stochastic Dynamic Optimal Power Flow (DSOPF), DSOPF Application to the Smart Grid, Static Security Assessment (SSA) and Contingencies, Contingency Studies for the Smart Grid, application of smart grid

- **STABILITY ANALYSIS TOOLS FOR SMART GRID** **(08 Hours)**

  Introduction to Stability, Voltage Stability Assessment, Voltage Stability and Voltage Collapse, Classification of Voltage Stability, Static Stability (Type I Instability), Dynamic Stability (Type II Instability) , Angle Stability Assessment, Transient Stability , State Estimation

- **POWER QUALITY MANAGEMENT IN SMART GRID** **(06 Hours)**

  EMC in smart grid, equipment required for grid connected systems, grid connection requirements from power provider, addressing safety and power quality for grid connection, metering and rate arrangement for grid connected systems, Web based power quality monitoring.

Total Hours: 45

3. BOOKS RECOMMENDED:

1. James Momoh, “Smart grid: fundamentals and design”, John Wiley & Sons, New Jersey 2012,
2. Bharat Modi, Anu Prakash, Yogesh Kumar, “Fundamentals of smart grid technology”, S.K.Kataria & sons, Delhi, 2019
3. A. Keyhani, “Smart Power Grid Renewable Energy Systems”, John Wiley & Sons, New Jersey 2011.
4. Shady S. Refaat, Omar Ellabban, Sertac Bayhan,Haitham Abu-Rub, Frede Blaabjerg and Miroslav M. Begovic, Smart Grid and Enabling Technologies, IEEE Press, John Wiley & Sons Ltd, 2021.
5. Janaka Ekanayake, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama and Nick Jenkins, Smart Grid Technology and Applications, John Wiley & Sons,2012
6. I.S. Jha, Subir Sen, Rajesh Kumar and D.P. Kothari, “Smart Grid: Fundamentals & Applications, New Age International publishers, New Delhi, 2019.

Simulation and Hardware implementation of various Charging infrastructure for Electric Vehicles

M. Tech. (EEPE92) **Simulation and Hardware implementation of various Charging circuits for EV Battery Systems**	**Scheme**	**L**	**T**	**P**	**Credit**
		0	**0**	**10**	**5**

<u>Course outcomes</u>:

At the end of this course the students will be able to

CO1	learn various charging circuits for EV battery system
CO2	Simulate various PE converter topologies for battery charging
CO3	Simulate different control techniques for battery charging
CO4	Analyse and compare the performances of different control techniques
CO5	design and develop a laboratory prototype of charging circuits for EV battery system.

Syllabus		
1.	Electric Vehicle Technology and Charging Equipment, Basic charging Block Diagram of Charger, Difference between Slow charger and fast charger, Slow charger design rating, Fast charger design rating, AC charging and DC charging, On-board and off-board charger specifications	08
2.	Selection of converter devices, design of filter components	04
3.	Grid integration and bidirectional power flow in the EV chargers	04
4.	Battery terminologies and basic battery models	04
5.	Concept of inductive and wireless charging	04
6.	Battery Management System and SoC Estimation methods	20
	Notional Hours: A	44

<u>Laboratory experiments:</u>

Sl. No.	**Name of the Experiment**	**Hours**
Simulation of various topologies of PE converters for charging		
1.	PFC boost rectifier	04
2.	Interleaved PFC boost rectifier	04
3.	PWM rectifier operating in open loop	04
4.	Closed loop control of Bidirectional operation of PWM rectifier	08
5.	Simulation of 3-phase Phase Locked Loops (PLL)	04
6.	Open loop and closed loop control of Dual Active Bridge DC-DC Converter for battery charging	24

	(a) Single phase shift operation (b) Double Phase shift operation (c) Triple Phase shift operation	
7.	Battery modelling and verification of the model	04
	Notional Hours: B	56
Mini Project		
The mini project may be Hardware implementation of any of the above charging circuit. It may be in any of the platform as per the preference of the student and the course teachers.		80
1.	Continuous Evaluation	20
	Notional Hours: C	100
	Total Notional Hours: (A+B+C)	200

Books Recommended:

1. Ned Mohan, Tore M. Undeland and William P. Robbins, "Power Electronics Converters, Applications, and Design", John Willey & Sons, Inc., 2nd Edition, 1995
2. M. Abul Masrur, Chris Mi . "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", 2nd Edition, 2017
3. Robert W. Erickson , Dragan Maksimović "Fundamentals of Power Electronics", Third Edition, 2020.
4. Ottorino Veneri, "Technologies and Applications for Smart Charging of Electric and Plug-in Hybrid Vehicles", Springer, 2017

ANNXURE- II

Post Graduate Programme

M. Tech.
in
Power Systems

Curriculum
(as per NEP)

सरदार वल्लभभाई राष्ट्रीय प्रोद्योगिकी संस्थान, सूरत

SARDAR VALLBHBHAI NATIONAL INSTITUTE OF TECHNOLOGY, SURAT

विधुत इंजीनियरिंग विभाग

DEPARTMENT OF ELECTRICAL ENGINEERING

SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY, SURAT
DEPARTMENT OF ELECTRICAL ENGINEERING
Teaching Scheme: M.Tech. in Power Systems

Sr. No.	Subject	Code	Scheme L-T-P	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
				Th. Marks	T Marks	P Marks		
	First Semester							
1	Computer Aided Power System Analysis (Core-1)	EEPS101	3-1-2	100	25	50	05	100
2	Power System Protection (Core-2)	EEPS103	3-1-2	100	25	50	05	100
3	Restructuring in Power Systems	EEPS105	3-1-0	100	25	00	04	70
4	Elective-1	EEPS1XX	3-0-0	100	-	-	03	55
5	Elective-2	EEPS1XX	3-0-0	100	-	-	03	55
						Total	**20**	**380**
6	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	EEPE91 EEPE93	0-0-10				5	200 (20 x 10)
	Second Semester							
1	Power System Dynamics and Control (Core-IV)	EEPS102	3-1-2	100	25	50	05	100
2	Applications of Power Electronics in Power Systems (Core-V)	EEPS104	3-1-2	100	25	50	05	100
3	Elective-3	EEPS1XX	3-0-0	100	-	-	03	55
4	Elective-4	EEPS1XX	3-0-0	100	-	-	03	55
5	Institute Elective	EEPS1XX	3-0-0	100			03	55
6	Mini Project	EEPS106	0-0-4	00	00	50	02	70
						Total	**21**	**435**
7	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	EEPS92 EEPS94	0-0-10				5	200 (20 x 10)
	Third Semester							
1	MOOC course- I* (Swayam/NPTEL)	Φ-NPTEL-SWM-301-304/ NPTEL-SWM401-404	3/4-0-0	100	00	00	3/4	70/80
2	MOOC course- II* (Swayam/NPTEL)	Φ-NPTEL-SWM-301-304/ NPTEL-SWM401-404	3/4-0-0	100	00	00	3/4	70/80

3	Dissertation Preliminaries	EEPS295	0-0-28	-	-	350$	14	560
						Total	**20-22**	**700-720**
	Fourth Semester							
1	Dissertation	EEPS296	0-0-40	-	-	600$	20	800
						Total	20	800

List of Elective Subjects

Elective-1

Sr. No	Code	Subject
01	EEPS111	Digital Signal Processing
02	EEPS113	Power Electronics
03	EEPS115	Distributed Generation
04	EEPS117	Power Quality
05	EEPS119	Microcontroller Based System Design

Elective-2

Sr. No	Code	Subject
01	EEPS131	Power System Transients
02	EEPS133	Forecasting and Planning Methods
03	EEPS135	Operation and Analysis of Distribution System
04	EEPS137	Electrical Machine for Renewable Energy Generation
05	EEPS139	System Theory

Elective-3

Sr. No	Code	Subject
01	EEPS112	High Voltage Engineering & EHV AC Transmission
02	EEPS114	Electric Vehicle Technology
03	EEPS116	Cryptography and Cyber Security
04	EEPS118	Advance Power Converters for Renewable Energy Applications
05	EEPS120	Insulation Engineering

Elective-4

Sr. No	Code	Subject
01	EEPS142	Renewable Energy Sources
02	EEPS144	HVDC Transmission
03	EEPS146	Energy Audit
04	EEPS148	Advanced Energy Storage Devices and Applications
05	EEPS150	Wide Area Power System Control

Institute Elective

Sr. No	Code	Subject
01	EEPS172	Advanced Optimization Methods
02	EEPS174	Advanced Numerical Methods
03	EEPS176	Artificial Intelligence and Machine Learning
04	EEPS178	Reliability Evaluation of Electrical Systems
05	EEPS180	Energy Storage and Management

M. Tech. Power System, Ist year, Semester I

COMPUTER AIDED POWER SYSTEM ANALYSIS

EEPS101

L	T	P	Credit
3	1	2	05

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	To formulate Power flow problems.
CO2	Solving power flow problems by various methods.
CO3	Formulate and solve the optimum power flow problem.
CO4	Analysis of faulted power systems.
CO5	Contingency analysis of power systems with single and multiple contingencies.
CO6	Application of Least Square method for power system state estimation.

2. Syllabus

- **Mathematical preliminaries** **04 hrs.**
- LU Decomposition methods: Crout, Shipley, Dolittle, Sparse matrix computations
- **Power Flow Analysis** **09 hrs.**
  Power flow problem formulation, Construction of Ybus matrix including magnetic coupled lines and transformer by various methods: Direct, Primitive matrices, Graph Theory, Near-optimal ordering of bus number, Gauss-Seidel method, Newton-Raphson method, Fast Decoupled method, DC load flow, AC-DC load flow, distribution system load flow.
- **Economic Dispatch and Optimum Power Flow** **06 hrs.**
  Classical optimization method with and without constraints, Lossless Generation Dispatch, Economic Dispatch including Losses, Optimum Power Flow Formulation and its solution by Gradient and Newton's method.
- **Short Circuit Analysis** **09 hrs.**
  Thevenin's impedance at bus and between two buses, Modifications to existing Zbus, Zbus algorithm to construct Zbus matrix, Power Invariant transformation, Balanced fault analysis using conventional method and Zbus, Selection circuit breaker, Symmetrical components and sequence networks of various components, Analysis of system with unbalanced faults (LG, LL, LLG) using Zbus matrix, open conductor faults
- **Power System Contingency Analysis** **09 hrs.**
  Concept of compensating currents for simulation of adding and removing multiple lines, Analysis of single contingencies, Analysis of multiple contingencies, contingency analysis by dc model
- **Power System State Estimation** **08 hrs.**
  Need for power system state estimation, Least Squares method, Basics of Statistics, Test for Bad data, the structure and formation of Hx, Line only algorithm

Total Hours-45

3. Books Recommended:

1 Power System Analysis by John J. Grainger and William D. Stevenson, Tata McGraw Hill Education Private Limited, New Delhi, Edition 2003

2 Power Generation Operation and Control by Allen J. Wood and Bruce F. Wollenberg, John Wiley & Sons Inc, Second Edition

3 Power System Analysis by Hadi Saadat, Tata McGraw Hill Publishing Company Limited, New Delhi, Edition 2002

4 Power System Analysis and Design by J. Duncan Glover, Mulukutla S. Sarma and Thomas J. Overby, Thomson Corporation, Fourth Edition
5 Power System Analysis by Arthur R. Bergen and Vijay Vittal, Pearson Education India, Second Edition
6 Computer analysis of power systems by Arrillaga, J and Arnold C.P, John Wiley and Sons, New York, 1997
7 Computer Techniques in Power System Analysis by Pai M. A., Tata McGraw hill, New Delhi, 2006
8. Computational methods for Electric Power Systems by Mariesa L. Crow, Second Edition, CRC Press

4. List of Experiments.

1 Solution of Linear Algebric equations using Gauss elimination, Crout's, Dolittle and Shipley method.
2 Solution of Linear Electrical circuit by Cut set and Tie set method.
3 Generalized program for determing Ybus of given netwrok.
4 Generalized program for determing load flow of given netwrok using G-S method.
5 Generalized program for determing load flow of given netwrok using N-R method.
6 Generalized program for determing load flow of given netwrok using FDLF method.
7 Load flow simulation of given network in ETAP.
8 Load flow simulation of given network in POWERWORLD.
9 Optimum Power Flow using MATPOWER.
10 Generalized program for determing Zbus of given netwrok.
11 Generalized program for conducting short circuit analysis on given network.
12 Short circuit analysis of given network using ETAP, POWERWORLD.
13 Generalized program for conducting State-Estimation on given network.

Note: Tutorials will be conducted separately for 15 hours

M. Tech. Power System, Ist year, Semester I

POWER SYSTEM PROTECTION

EEPS103

L	T	P	Credit
3	1	2	05

1. **Course Outcomes (COs):**

At the end of the course, the students will be able to:

CO1	Analyse power system faults for balanced and unbalanced conditions.
CO2	Apply the fundamental principles of protective devices for the protection of various electrical items.
CO3	Describe current and voltage transformers and their impact on protection scheme performance.
CO4	Identify, apply, and calculate settings for power lines, transformer, generator, and bus bar protection schemes.
CO5	Illustrate the concepts of microprocessor based protective relays and digital relaying algorithms.

2. **Syllabus**

- **Review Of Principles of Power System Protection** **04 Hrs.**
  General philosophy of protection, Relay terminology, Review of Relay characteristics, Classification of Relays, characteristics and operating equation.
- **Instrument Transformer for Relaying** **04 Hrs.**
  Performance of conventional CT/PT as well as capacitive voltage transformers. Principle of operation of magneto optic CT/ PT. Standards, effect on relaying philosophy.
- **Network Protection with Renewable Sources** **07 Hrs.**
  Fault characteristics of renewable Sources, Protection of distribution and transmission networks in the presence of renewables
- **Apparatus Protection** **15 Hrs.**
  Protection of generator, motor, transformer, transmission line and bus-bar. Relay co-ordination. Pilot wire protection, carrier current protection. Testing of relay.
- **Philosophy Of Numerical Relaying** **15 Hrs.**
  Introduction, Anti –aliasing Filters, sampling, Measurements principles using Fourier and other algorithms and its application for implementation of various numerical relays. Algorithms for transmission line, transformer & bus bar protection; out-of-step relaying, Introduction to adaptive relaying & wide area measurements.

Total Hours-45

Note: Tutorials will be conducted separately for 15 hours

3. **Books Recommended:**

1 Bhuvanesh Oza, N.C. Nair, R.P.Mehta, V.H.Makwana “Power System Protection and Switchgear”, Tata 2010

2 Y.G. Paithankar, S.R. Bhide,“Fundamentals of Power System Protection” PHI,2008

3 J. Lewis Blackburn,’Protective Relaying’ Marcel Dekker INC. 1997

4 Arun G. Phadke, James S. Thorp,”Computer Relaying For Power Systems” John Willey & sons

5 Badri Ram, D N Vishwakarma, “ Power System Protection and Switchgear’, Tata Mc Graw Hill, 2005

6 Prof. S. A. Soman,"Web course on Power System Oritection" on the website http://nptel.iitm.ac.in

4. List of Experiments

1. To study and simulate the generation of standard impulse voltage using MATLAB Simulink.
2. (a) To simulate magnetizing inrush current of 1-phase transformer on MATLAB Simulink.
   (b) To observe magnetizing inrush current waveform of transformer.
3. (a) To study transient by applying sudden short-circuit on 3-phase synchronous generator using MATLAB 7 Simulink.
   (b) To observe the short circuit current by applying sudden short-circuit on 3-phase synchronous generator.
4. To study and obtain characteristics of IDMT numerical relay for over & under voltage protection.
5. To study the coordination of IDMT relays for the protection of radial feeder.
6. To study the concepts of directional relay and its application in parallel feeder protection
7. To study different protections of 3-phase induction motor using numerical relay.
8. To study different protection schemes of generator protection.

M. Tech. Power System, Ist year, Semester I

	L	T	P	Credit
RESTRUCTURING IN POWER SYSTEMS	**3**	**1**	**0**	**04**

EEPS105

1. **Course Outcomes (COs):**

At the end of the course, the students will be able to:

CO1	The students would be able to understand the basics and benefits of restructuring and deregulations.
CO2	The students would be able to evaluate the market scenario and completion in deregulated environment.
CO3	The students would be able to understand the pricing and agreements associated with deregulation policies.
CO4	The contingency and ancillary service management will be explored for restructured and deregulated system.
CO5	The impact of availability and unavailability in terms of reliability indices will be explored for power system network.

2. **Syllabus**

- **Deregulation Of the Electricity Supply Industry** **06 hrs.**
  Deregulation, Reconfiguring Power systems, unbundling of electric utilities, Background to deregulation and the current situation around the world, benefits from a competitive electricity market, after-effects of deregulation.
- **Power System Operation in Competitive Environment** **11 hrs.**
  Role of the independent system operator, Operational planning activities of ISO: ISO in Pool markets, ISO in Bilateral markets, Operational planning activities of a GENCO: Genco in Pool and Bilateral markets, market participation issues, competitive bidding.
- **Transmission Open Access and Pricing Issues** **08 hrs.**
  Power wheeling, Transmission open access, pricing of power transactions, security management in deregulated environment, and congestion management in deregulation.
- **Ancillary Services Management** **08 hrs.**
  General description of some ancillary services, ancillary services management in various countries, reactive power management in some deregulated electricity markets.
- **Reliability and Deregulation** **12 hrs.**
  Reliability analysis: interruption criterion, stochastic components, component models, calculation methods, Network model: stochastic networks, series and parallel connections, minimum cut sets, reliability costs, Generation, transmission and distribution reliability, Reliability and deregulation: conflict, reliability analysis, effects on the actual reliability, regulation of the market.

Total Hours-45

Tutorials will be conducted separately for 15 hours

3. **Books Recommended:**

1 K. Bhattacharya, MHT Bollen and J.C Doolder, “Operation of Restructured Power Systems”, Kluwer Academic Publishers, USA, 2001.
2 Lei Lee Lai, “Power System restructuring and deregulation”, John Wiley and Sons, UK. 2001.
3 Fred I Denny and David E. Dismukes, “Power System Operations and Electricity Markets”, CRC Press, LLC, 2002.

M. Tech. Power System, Ist year, Semester I

	L	T	P	Credit
DIGITAL SIGNAL PROCESSING	**3**	**0**	**0**	**03**

EEPS111 (Elective I)

1. **Course Outcomes (COs):**

At the end of the course, the students will be able to:

CO1	Classify the discrete time signals and systems and analyze the system stability.
CO2	Design optimum structures for realizing IIR and FIR systems.
CO3	Analyze the signals using frequency domain analysis.
CO4	Design and implement different types of FIR/IIR filters.
CO5	Apply signal processing techniques to real situation problems.

2. **Syllabus**

- **Discrete Time Signals and Systems** **13 hrs.**
  Classification Of Discrete Time Signals and Systems, Quantization Error, Stability Analysis, Correlation, Sampling Theorem, Aliasing, Z-Transforms And Its Application To The Analysis Of LTI Systems, Realization Of Discrete-Time Systems: Direct Form – I, II, Recursive And Non-Recursive Realization.
- **Discrete Time Fourier Transform** **14 hrs.**
  Definition and properties of DTFT and DFT and their inverses, efficient computation of DFT: FFT algorithms: DIT and DIF, Time-domain aliasing, Application of DFT in linear filtering: Overlap and save, Overlap and add methods
- **Digital Filters** **14 hrs.**
  Concept of filtering, phase and group delays, Design of IIR filters from analog filters (Butterworth and Chebyshev) by impulse invariance and bilinear transformation, Windowing techniques for FIR filter design, Selection of window function based on the specification.
- **Applications Of DSP** **04 hrs.**
  Applications of DSP to power electronics/ power system/ Instrumentation.

Total Hours-45

3. **Books Recommended:**

1 Sanjit Mitra, Digital Signal processing, McGraw-Hill Science/Engineering/Math; 3 edition, 2005.
2 Proakis-Manolakis, Digital signal Processing, 3rd edition, PHI, 2000.
3 Oppenheim-Schetor, Discrete time signal processing, 2nd edition, Prectice Hall, 1997.
4. Schaum's outline: Digital Signal Processing, Monson H. Hayes, McGraw Hill.
5. Introduction to Digital Signal Processing by Jonny R. Johnson, Prentice Hall India Learning Private Limited.

M. Tech. Power System, I[st] year, Semester I

POWER ELECTRONICS (Elective I)

EEPS113

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	To understand the concept of Power semiconductor devices and also design magnetic components.
CO2	To Analyze various types of DC-DC converters.
CO3	To develop various PWM schemes for inverters.
CO4	To describe the operation of various line commutated converters.
CO5	To categorize various multi-level inverters & resonant converters.

2. Syllabus

- **Review of Power Semiconductor Devices** **08 hrs.**
  Review of Power semiconductor devices, Gate and Base drive circuits - Preliminary design considerations, Temperature control of power devices, Heat sink design, and Design of Magnetic components. Introduction to Wide Band gap semiconductor devices (SiC & GaN)
- **DC-DC Converters** **10 hrs.**
  Buck converter, Boost converter, Buck-Boost converters, CUK converter, Fly-back converter, Forward converter, Push-pull converter, Full bridge and Half bridge converters, Design considerations and comparison.
- **Inverters** **10 hrs.**
  Review of single-phase bridge inverters, 3-phase bridge inverters, Pulse width modulated inverters, 1-pulse and multi pulse modulation, Sinusoidal PWM, Space Vector PWM, Reduction of harmonics - Selective Harmonic Elimination Technique.
- **Line Commutated Converters** **10 hrs.**
  Principle of phase control, Review of single-phase converters, 3 phase half and fully controlled converters, 12-pulse converter, Dual converters.
- **Introduction to Multilevel and Resonant Converters** **07 hrs**.
  Principle and operation of Neutral Point clamped, Flying capacitor and Cascaded H-Bridge inverters. Principle and Operation of Load Resonant, ZCS and ZVS converters.

Total Hours-45

3. Books Recommended:

1 Rashid, M. H., "Power Electronics Handbook", Elsevier Academic Press, 2001.
2 Ned Mohan, Tore M. Undeland and William P. Robbins, “Power Electronics Converters, Applications, and Design”, John Willey & Sons, Inc., 2nd Edition, 1995.
3 Agrawal, J. P., "Power electronic systems: Theory and design" Addison Wesley Longman (Singapore) Pte. Ltd. New Delhi, 2001.
4. Rashid, M. H., "Introduction to PSpice Using OrCAD for Circuits and Electronics, Prentice-Hall of India Pvt. Ltd., New Delhi, Eastern Economy Edition, Third Edition 2006.
5. Joseph Vithayathil, "Power Electronics: Principles and Applications", Mcgraw-Hill, 1995.
6. Erickson Robert W., Maksimovic Dragan, "Fundamentals of Power Electronics", Kluwer Academic Publishers Group (Netherlands), 2001.
7. A. Pressman, “Switching Power Supply Design”, McGraw-Hill, 1998.

M. Tech. Power System, Ist year, Semester I

DISTRIBUTED GENERATION (Elective I)

EEPS115

L	T	P	Credit
3	0	0	03

1. **Course Outcomes (COs):**

At the end of the course, the students will be able to:

CO1	Understand the necessity of Distributed Generation in distribution system.
CO2	Analyze micro-grids and investigate the different types of interfaces of DGs to microgrid.
CO3	Evaluate the impact of integration of Distributed Generation in protection scheme.
CO4	Appraise and evaluate the economic impact of DG integration in distribution system.
CO5	Evaluate various control aspects of DG in distribution system.

2. **Syllabus**

- **Distributed Generation** **14 hrs.**
  Gas turbine powered distributed generators, Electric vehicle as a Distributed generator (V2G, G2V), Fuel cell powered distributed generators, renewable resource distributed generators, Energy storage with distributed generators: Superconducting magnetic energy storage (SMES), capacitor storage, mechanical storage; Flywheels, pumped and compressed fluids, comparison of energy storage system, Hydrogen Technologies, Electric Vehicles
- **Micro Grid** **8 hrs.**
  Resources evaluation and needs, dimensioning integration systems, Optimizing integration systems, Integration systems control, Cases of study: multi-generation buildings
- **Planning & Operation of Distributed Generation** **11 hrs.**
  DG planning cost implications of power quality, cost of energy and net present value calculations and implications on power converter design, Power converter topologies and model and specifications for DG applications, Capacitor selection, choice of DC bus voltage, current ripple, capacitor aging and lifetime calculations. Voltage control techniques, reactive power control, Harmonics and power quality issues.
- **Protection in Distributed Generation** **12 hrs.**
  Introduction, over current protection, Distance protection, Differential protection, Protection coordination, Renewable energies protection, Distributed grid protection, Problems in distributed grids, Integration of mini and micro-generation in distribution grids, V2G integration, Islanding Schemes.

Total Hours-45

3. **Books Recommended:**

1 J.N.Twidell & A.D.Weir-Renewable Energy Sources, University press,Cambridge.
2 Sukhatme, S.P., Solar Energy -Principles of Thermal Collection and Storage, Tata McGraw-Hill, New Delhi.
3 Kreith, F., and Kreider, J.F., Principles of Solar Engineering, Mc-Graw-Hill Book Co.
4. S.L.Soo ,Direct Energy Conversion , Prentice Hall Publication
5. James Larminie, Andrew Dicks, Fuel Cell Systems, John Weily & Sons Ltd
6. J. F. Manwell, J. G. McGowan, A. L. Rogers, Wind Energy Explained John Weily & Sons Ltd
7. E.J. Womack, MHD power generation engineering aspects, Chapman and Hall Publication.
8. G.D. Rai, Non Conventional energy Sources, Khanna Publications, New Delhi.

M. Tech. Power System, Ist year, Semester I

POWER QUALITY (Elective I)

EEPS117

L	T	P	Credit
3	0	0	03

1. **Course Outcomes (COs):**

At the end of the course, the students will be able to:

CO1	Describe various power quality issues.
CO2	Identify different methods to solve the power quality problems.
CO3	Apply passive and active compensation methods for solving power quality problems.
CO4	Analyze various modes of unified power quality conditioner.
CO5	Design active power filters for various operating conditions.
CO6	Summarize the benefits of using the power quality improvement devices.

2. **Syllabus**

- **Introduction to Power Quality:** **05 hrs**
  Definition, Power Quality Problems, Causes and Consequences, voltage sags, swells, interruptions, flicker, reactive power and harmonics. Power quality indices, IEEE and IEC standards related to power quality.
- **Origin of power quality variations** **05 hrs**
  Voltage Frequency Variations, Voltage Magnitude Variations, Voltage Unbalance, Voltage Fluctuations and Light Flicker, Waveform Distortion
- **Origin of power quality events** **08 hrs**
  Interruptions: Terminology, Causes, Restoration and Voltage Recovery. Voltage Dips: Causes of Voltage Dips, Voltage-Dip Examples, Voltage Dips in Three Phases, Phase-Angle Jumps Associated with Voltage Dips, Voltage Recovery After a Fault. Transients: Lightning Transients, Normal and Abnormal switching transients
- **Shunt and Series compensation** **15 hrs**
  Passive shunt compensation, Active load compensation, D-STATCOM - Design, Control and Phasor Analysis.
  Dynamics of sags and swells, Passive Series Compensation, Active Series Compensation- Dynamic Voltage Restorer (DVR) with and without energy support- Design, Control and Phasor Analysis.
- **Unified Power Quality Conditioner (UPQC)** **04 hrs**
  Right Shunt and Left Shunt Topologies, Phasor Analysis of UPQC-P, Q and S under various perturbations.
- **Active power filters** **08 hrs**
  Voltage and Current Harmonics- Causes and Consequences. Design of Passive Filters. Active Shunt Filters and Active Series Filters, Hybrid Filters, Improved Power Quality Converters.

Total Hours-45

3. **Books Recommended:**

1 Bollen Math H.J. ,GUIrene Y.H., “Signal Processing of Power Quality Disturbances”, Wilely Inter science Publication (IEEE Press),2006.

2 Bhim Singh, Ambrish Chandra, and Kamal Al-Haddad, Power Quality: Problems and Mitigation Techniques, John Wiley and Sons, United Kingdom, Dec. 2014
3 Arindam Ghosh and Gerard Ledwich, Power Quality Enhancement using Custom Power Devices, Springer Science and Business Media, New York, Dec. 2012.
4 Wakileh George J."Power System Harmonics: Fundamentals, analysis and filter Design," Springer,(first Indian reprint) 2007.
5 Hirofumi Akagi, Edson Hirokazu Watanabe and Mauricio Aredes, Instantaneous Power Theory and Applications to Power Conditioning, John Wiley and Sons, New Jersey, March, 2007

M. Tech. Power System, Ist year, Semester I

MICROCONTROLLER BASED SYSTEM DESIGN (Elective I)

EEPS119

L	T	P	Credit
3	**0**	**0**	**03**

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Revise basic concepts of 8051 microcontrollers and embedded ‘C’ programming.
CO2	Explain architecture of CIP 51 8-bit microcontroller with the advanced features of the controller.
CO3	Describe the functionality of Programmable internal and external peripherals of CIP 51.
CO4	Write embedded ‘C’ code for CIP51 with the exposure of SI Lab IDE.
CO5	Develop microcontroller-based prototype for automation, power electronics based electrical systems and other real-world problems.

2. Syllabus

- **Review of 8051 Architecture & Embedded ‘C’ Programming** **07 hrs.**
  Introduction, 8051 family microcontrollers, hardware architecture, input/output pins, I/O ports and circuits, general purpose registers, special function registers, timers-counters, concepts of interrupts.
  Variables and constants, storage classes, enumerations and definitions, I/O operations, control statements, functions, pointers and arrays, structure and unions, interrupt service routines.
- **Introduction To Cip-51 Controller Architecture** **10 hrs.**
  Memory Map, Instruction Pipeline, PLL & Clock System, concept of Crossbar and Pin assignment, On Chip Peripherals: Timer/Counters, GPIO, ADC, DAC, UART.
- **Hardware Concepts and Programming of Cip-51 Peripherals** **14 hrs.**
  Comparator, SPI & I2C serial Communication interface, MAC unit on CIP-51, Programming of PCA, ADC, DAC. Interfacing of seven-segment LED, LCD display, relay, Pushbutton keys, Matrix key board and Stepper motor.
- **Applications** **14 hrs.**
  Design of digital Multimeter, numerical relay, control of DC – DC Converters, DC-AC inverters.

Total Hours-45

3. Books Recommended:

1 Muhammad Ali Mazidi, Rolin McKinlay and Janice Gillispie Mazidi “The 8051 Microcontroller and Embedded Systems: Using Assembly and C” Pearson 2nd edition, 2007.

2 M. Mazidi, J. G. Mazidi and R. D. McKinlay, The 8051 Microcontroller and Embedded Systems, Prentice Hall of India, 3rd edition, 2007.

3 Mark Siegesmund, Embedded C Programming: Techniques and Applications of C and PIC MCUS, Elsevier Science, 1 st Edition 2014.

4. Chew Moi, Gourab Sen Gupta “Embedded Programming” Silicon Labs 8-bit MCUniversity Program.

5. Datasheet of SILABS C8051FXXX. (www.silabs.com)

6. Application notes from SILAB C8051FXXX.

M. Tech. Power System, Ist year, Semester I

POWER SYSTEM TRANSIENTS (Elective I)

EEPS131

L	T	P	Credit
3	0	0	03

1. **Course Outcomes (COs):**

At the end of the course, the students will be able to:

CO1	To study Generation of switching transients and their control
CO2	To distinguish between various switching transients and lightning surges.
CO3	To observe the behavior of travelling waves such as the propagation, reflection and refraction of travelling waves.
CO4	To study the effect of voltage transients caused by faults, circuit breaker action, load rejection on integrated power system.
CO5	Determine the skill to design the protection scheme of power system equipment using ground wires, surge absorbers and arrestors.

2. **Syllabus**

- **Over voltages in Power Systems** **12 hrs.**
  Transient over voltages due to lightning, Theory of ground wires, Direct stroke to a tower, Effect of reflection up and down the tower, Tower grounding and counterpoises, Switching transients, Single and double frequency transients, Abnormal switching transients, Capacitance switching, Kilometric fault, Line dropping and load ejection, Closing and reclosing of lines, High charging currents, Over voltages induced by faults, Ferro-resonance, Switching transients in integrated systems, Peaking switching over voltages in EHV lines and cables.
- **Travelling Waves in Transmission Lines** **13 hrs.**
  Origin and nature of power system transients, Traveling waves on transmission lines, General wave equation, Attenuation and distortion of waves, Reflection and refraction of traveling waves at different line terminations, Bewley Lattice Diagram, Traveling waves in multi-conductor systems, Transition points on multiconductor circuits.
- **Protection Against Travelling Waves** **08 hrs.**
  Rod gap, Arcing Horn, Lightning Arresters, Surge Absorber, Insulation Coordination
- **Transient In Transformers and Rotating Electrical Machines** **12 hrs.**
  High frequency transients and voltage distribution in windings of transformer and rotating electrical machines, Surge impedance

Total Hours-45

3. **Books Recommended:**

1 I.V. Begley, 'Traveling waves in Transmission Systems', John Wiley (1933,51), Dover.
2 R. Rudenberg. 'Electric Stroke waves in Power Systems', Harvard University Press, Cambridge, Massachusetts.
3 Allan Greenwood, 'Electric Transients in Power Systems', Wiley Interscience.
4. C.S. Indulkar and D.P. Kothari, 'Power System Transients, A Statistical Approach', Prentice-Hall of India Pvt. Ltd., New Delhi. 110 001.
5. V.A. Venikov,'Transient phenomena in Electrical Power Systems', Pergamon Press, London.

M. Tech. Power System, Ist year, Semester I

FORECASTING AND PLANNING METHODS (Elective II)

EEPS133

L	T	P	Credit
3	0	0	03

1. **Course Outcomes (COs):**

At the end of the course, the students will be able to:

CO1	The students would be able to understand the basics of forecasting and planning for engineering.
CO2	The students would be able to learn methods of time series decomposition and its smoothing for better forecasting and planning.
CO3	The students would be able to learn various simple and multiple regression models for forecasting.
CO4	The students would learn the BOX-Jenkins and ARIMA for forecasting
CO5	The students would be able to learn the basics of planning for engineering applications.
CO6	The students would be able to learn various methods of planning and their applications.

2. **Syllabus**

- **Fundamentals of Forecasting** **04 hrs.**
  The forecasting perspective, Current Status Of Forecasting, Fundamentals Of Quantitative Forecasting, Explanatory And Time Series Forecasting, overview of forecasting techniques and basic steps, basic forecasting tools, time series, and cross-sectional data, time plots, time series patterns, seasonal plots, scatterplots, univariate and bivariate statistics, autocorrelation, measuring forecast accuracy, standard accuracy, out-of-sample accuracy, ACF of forecast error, prediction intervals, least square estimates, transformation and adjustments.
- **Time-series decomposition and Exponential smoothing methods** **08 hrs.**
  Principle of decomposition, model, graphics, seasonal adjustment, moving averages, simple, centred, double moving and weighted moving averages, local regression smoothing, classical decomposition, additive and multiplicative decomposition, variations on classical decomposition, census bureau methods, first iterations, later iterations, extensions to X-12 ARIMA, STL decomposition, comparing STL with X-12 ARIMA, Exponential smoothing methods: The forecasting scenario, averaging methods, the mean, moving averages, exponential smoothing methods, single exponential smoothing and its adaptive approach, Holt's linear method, Holt-Winter's trend and seasonality method, exponential smoothing: Pegel's classification, general aspects of smoothing methods
- **Simple and multiple Regression** **08 hrs.**
  Simple regression: Regression methods, simple regression, least squares estimation, the correlation coefficient, residuals, outliers and influential observations, inference and forecasting with simple regression, regression as statistical modelling, The F-test for overall significance, confidence intervals for individual coefficients, t-tests for individual coefficients, forecasting using the simple regression model, non-linear relationship, non-linearity in the parameters, using logarithms to form linear models, local regression Multiple Regression: Introduction, theory and practice, solving for the regression coefficients, multiple regression and coefficient of determination, The F-test for overall significance, individual coefficients, t-tests for individual coefficients, regression with time series, selecting variables, multicolinearity, forecasting using the multiple regression model.
- **The BOX-JENKINS methodology for ARIMA models** **06 hrs.**
  Examining correlation in time series data, the autocorrelation function, white noise model, sampling distribution of autocorrelation, the partial autocorrelation coefficient, recognizing seasonality,

examining stationarity of time series data, random walk model, tests for stationarity, seasonal differencing, backshift notion, ARIMA models of time series, autoregressive model of order one, moveing average model of order one, higher order models, Mixtures ARIMA models, identification and estimation of parameters, forecasting with ARIMA.

- **Forecasting And Planning** **10 hrs**.
  The role of forecasting in planning, Comparison and selection of forecasting methods, the accuracy of forecasting methods, Pattern of the Data and its effects on individual forecasting methods, Time horizon effects on forecasting methods.
  Introduction to Planning: Defining planning as a discipline, multidisciplinary nature, role of a planner, fields of planning- Urban, regional, environmental, Electrical Infrastructure planning definitions and Basics of Planning, Goals and objectives of planning; Components of planning; Benefits of planning; Arguments for and against planning. Planning Process, Levels of Planning in India.
- **Planning Methods** **09 hrs.**
  Definition of development plan; Types: Master plan, Structure plan, District plan, Action area plan, Subject plan, Comprehensive planning, Zonal plans etc. Hierarchy of plans: Regional plan, Sub-regional plan; Sector plans and Spatial plans, Data requirements for planning; sources of primary and secondary data; questionnaire design, measurement scale and their application, sampling techniques, types of socio-economic surveys; self-surveys, interviews, questionnaires and observer participation, Data requirement for various types of regional plans; Techniques for conducting surveys.

Total Hours-45

3. **<u>Books Recommended:</u>**

1 Makridakis, Spyros, “Forecasting methods and application”, John Wiley, 1993.
2 X.Wang & J.R. Mc Donald, “Modern Power system planning”, McGraw. Hill, 1993
3 A.S Pabla , “Electrical Power system planning”, Mac Millan,Delhi,1998
4. Sullivan, “Power system planning”, McGraw. Hill, 1977
5. Lakervi E, E J Holmes, “Electricity distribution network design”, IEE, 2nd edition, 2003
6. A Reader in Planning Theory, Faludi, A., Pergamon Press, Oxford.
7. Planning Theory, Faludi, A., Pergamon Press, Oxford.
8. Regional Planning: Concepts, R.P. Mishra, 1992 Concept Publishing Techniques Policies
9. Planning Theory and Philosophy, Cambia, M., Taylor and Francis. Philosophy

M. Tech. Power System, Ist year, Semester I
OPERATION AND ANALYSIS OF DISTRIBUTION SYSTEM (Elective II)

L	T	P	Credit
3	0	0	03

EEPS135

1. **Course Outcomes (COs):**

At the end of the course, the students will be able to:

CO1	Recognize configuration of distribution feeder and understand load behaviour.
CO2	Determine voltage drop and power loss and develop system component models.
CO3	Analyze different methods of power flow and execute short circuit studies.
CO4	Perform voltage control analysis of electrical distribution systems.
CO5	Apply state estimation methods for distribution system.
CO6	Explain basic concept and identify appropriate protection scheme for distribution system.

2. **Syllabus**

- **Introduction to Distribution Systems** **04 hrs.**
  Structure of distribution system, distribution feeder configuration and substation layouts, construction and bus schemes, substation location and rating, overhead and underground distribution networks
- **Load Characteristic and Load Modelling, System Component Modeling** **07 hrs.**
  Definitions, Loads and Load Characteristics, loss factor, Load Growth and Diversified Demands, Load Models, feeder load; Overhead lines, feeders and cables, Single and three phase transformers, voltage regulators, capacitor banks, three phase induction machines, distributed generation.
- **Distribution System Analysis** **10 hrs.**
  Load flow analysis: Backward/forward sweep, Direct approach, Direct approach for weakly meshed systems, Gauss Implicit Z-matrix Method; Fault Studies: general short circuit theory, specific short circuits, backfeed ground fault currents, weakly meshed systems; case study.
- **Voltage Regulation in Distribution Systems** **04 hrs.**
  Basic Definitions, Quality of Service and Voltage Standards, Voltage Control, Feeder Voltage Regulators, LineDrop Compensation, Distribution Capacitor Automation, Voltage Fluctuations
- **State Estimations of Distribution System** **05 hrs.**
  Topology estimation, pseudo measurements, state estimation for radial distribution system, state estimation scheme, object-oriented state estimation, measurement placement, case study
- **Reliability Assessment of Distribution Systems** **04 hrs.**
  Introduction, reliability modelling concept, different reliability indices, customer interruption cost evolution and customer damage function
- **Distribution System Planning and Automation** **06 hrs.**
  Introduction, different components of distribution system planning, different planning approaches, planning models and solution strategies; introduction to distribution system automation, the basic elements of distribution system automation, power market deregulation and distribution system automation, load management at different peak and off-peak duration, compatibility of load management with system design and operation, smart grid and smart metering
- **Distribution System Protection** **05 hrs.**
  Basic Definitions, objective of distribution system protection, overcurrent protection devices, coordination of protective devices, high impedance faults, lightning protection, insulators.

Total Hours- 45

3. **Books Recommended:**

1 Turan Gonen, “Electric power distribution engineering”, CRC press, 2015

2 W. H. Kersting, “Distribution system modelling and analysis”, CRC press, 3rd edition, 2012

3 A.S Pabla, “Electrical Power system planning”, Mac Millan,Delhi,1998

4. V. Kamaraju, “Electrical power distribution systems”, Tata McGraw Hill, 2009

5. H. Lee Willis, “Power Distribution Planning Reference Book”, CRC Press, 1st edition, 2004

M. Tech. Power System, Ist year, Semester I	**L**	**T**	**P**	**Credit**
ELECTRICAL MACHINES FOR RENEWABLE ENERGY GENERATION (Elective II)	**3**	**0**	**0**	**03**

EEPS137

1. **Course Outcomes (COs):**

At the end of the course, the students will be able to:

CO1	Explain the fundamental issues and challenges of harvesting Renewable energy.
CO2	Analyze the different forms of energy storage by renewable energy sources.
CO3	Explain principle and construction, characteristics of electrical machines promising for renewable energy.
CO4	Compare existing machines and advanced renewable energy machines.
CO5	Identify the design modification of machines for renewable energy.
CO6	Select the appropriate electrical machines for harnessing renewable energy.

2. **Syllabus**

- **Forms of Energy Storage by Renewable Energy Sources** **02 hrs.**
  Kinetic energy, Potential Energy, Heat energy.
- **Classification of Electric Machines** **05 hrs.**
  Different of topologies of electric machines, Existing machines and Advanced machines for renewable energy
- **Existing Machines for Renewable Energy** **18 hrs.**
  Classifications Principle, construction and characteristics of Synchronous Generator, Induction Generator, Doubly Fed Induction Generator, Permanent Magnet Synchronous Generator, Linear Permanent Magnet Synchronous Generator.
- **Advanced Renewable Energy Machines** **20 hrs.**
  Classifications, Principle, construction characteristics and Application of Stator-PM Machines.
  Direct-drive PM Machines and Magnet less Machines

Total Hours-45

3. **Books Recommended:**

1 K.T. Chau. Electric Machines and Drives for Renewable Energy Harvesting, Energies, special issues, MDPI, 2017.
2 D.P. Kotahri, K.C. Singal, Rakesh RanjanRenewable Energy sources and emerging technologies, PHI, 2009
3 Pyrhonen, J.; Jokinen, T.; Hrabovcova, V. Design of Rotating Electrical Machines; Wiley: Chichester, UK,
2007.
4. D.S. Chauhan, S. K. Srivatava, Non- Conventional Energy Resources, New Age international Publishers, Third
edition,2014.
5. Selected Journal papers on Advanced Electrical machines for Renewable Energy.

M. Tech. Power System, Ist year, Semester I

SYSTEM THEORY (Elective II)

EEPS139

L	T	P	Credit
3	**0**	**0**	**03**

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Understand the concepts of vector spaces and subspaces.
CO2	Explain the concepts of linear algebra and its application to control theory.
CO3	Analyze discrete time systems with z-transforms.
CO4	Evaluate the stability of discrete time systems and obtain the state space representation of discrete time systems.
CO5	Design controllers and observers for discrete time systems.

2. Syllabus

- **Linear Algebra** **21 hrs.**
  Vector spaces, Basis, Operator, range of the linear operator, null space, rank, nullity, rank-nullity theorem, matrix representation of the linear operator in the bases, orthogonal bases, Inner product spaces, Holder inequality, Cauchy-Schwartz inequality, triangular inequality, Minkowski inequality, best approximation theorem , orthogonal projection lemma, Gram- Schmidtt orthogonalization, Characteristics polynomial, minimal polynomial, eigen value and eigen vector, Diagonal form, Triangular form, Caley- Hamilton Theorem.
- **System Theory** **24 hrs.**
  Introduction to Z transformation, bilateral and unilateral Z transformation, Z transformation of the important signals, Solving Discrete LTI system using Z transformation, Pulse transfer function, Phase space analysis of the discrete LTI system, Jury Stability criterion , Schur-Cohn test, Bilinear transformation applied with Routh's stability criterion. Conservative system, Controllability, Obsrvability, Observer Design, Diaphantile equation, Full order, reduced order, minimum order observer, Gopinath Observer, Luenberger Observer.

Total Hours-45

3. Books Recommended:

1 Kenneth Hoffmann And Ray Kunze, "Linear Algebra", PHI India limited, 1971.
2 K. Ogata, "Discrete-Time Control Systems", Prentice Hall; 2nd edition, 1995.
3 Allen V. Oppenheim, S. Willsky, with S. Hamid Navab ''Signals and systems" Prentice Hall; 2nd edition, 1996.
4. K. Ogata, "Modern Control Engineering", 3rd Edition, PHI India limited, 2001.
5. I. J. Nagrath and M. Gopal, "Control System Engineering", Anshan Publishers; 5th edition, 2008.

Energy Audit

M. Tech. (Electrical) (Power Systems) **Energy Audit** **EEPS91**	**Scheme**	**L**	**T**	**P**	**Credit**
		0	**0**	**10**	**5**

<u>Course outcomes</u>:

At the end of this course the students will be able to

CO1	Explain the energy audit process and its importance
CO2	Understand various standards related to energy audit
CO3	Assess the data collected from various sources for energy audit
CO4	Prepare the energy audit report
CO5	Perform case studies for different types of establishments

Sl. No.		**Hours**
1.	Introduction to Energy Audit: Global standards of Energy Audit, Direct and indirect benefits of energy audit, Energy Audit Process	25
2.	Types of Energy Audit: Preliminary and Detailed Audit, Visible Energy loss identification in walk through audit, Energy Audit criteria, Scope of energy Audit, Selection of Audit team Energy Audit Plan	25
3.	Preparation of Energy Audit: Collecting energy bills and data, Conducting preliminary analysis, Sample Energy flow charts	25
4.	Execution of Energy Audit: Data inventory and management, Graphical representation of data, Analysing Energy use pattern, Bench-marking and comparative analysis, Identifying Energy Saving Potential Cost benefit analysis	25
5.	Reporting of Energy Audit: Preparing Energy Audit Report with Recommendations, Preparing Action Plan, Implementing the action plan, Sample audit report	25
6.	ISO 50001 and Energy Management Case Studies: ISO 50001, Features of ISO 50001	25
7.	Case Studies of various types of buildings or industries etc.	50
	Total (Notional Hours)	200

Second Semester

M. Tech. Power System, Ist year, Semester II

POWER SYSTEM DYNAMICS AND CONTROL (Core-IV)
EEPS102

L	T	P	Credit
3	1	2	05

1. **Course Outcomes (COs):**

At the end of the course, the students will be able to:

CO1	Describe the fundamental concept of stability and the characteristics of Power system dynamics when subjected to different stresses
CO2	Develop dynamic modelling of power system components for stability studies
CO3	Investigate stability issues of single and multi-machines systems in power systems
CO4	Design the controllers to enhance the small signal stability of the power system
CO5	Interpret different schemes for improving transient stability and voltage stability.

2. **Syllabus**

- **Basic Concepts** **04 hrs.**
  Power system stability states of operation and system security, system dynamics problems, system model, analysis of steady State stability and transient stability, simplified representation of Excitation control.
- **Modeling of Synchronous Machine** **06 hrs.**
  synchronous machine, park's Transformation, Analysis of steady state performance, Equivalent Circuits of Synchronous machine, Determination of parameters of equivalent circuit, Transient Analysis of a Synchronous Machine.
- **Excitation System** **03 hrs.**
  Excitation System Modeling, Standard Block Diagram, System Representation by State Equations
- **Dynamics of a Synchronous Generator Connected To Infinite Bus** **06 hrs.**
  System Model, Synchronous Machine Model, Application of Model 1.1, Calculation of initial Conditions, System Simulation, Inclusion of SVC Model.
- **Analysis of Single Machine System** **04 hrs.**
  Small Signal Analysis, Application of Routh-Hurwitz Criterion, Small Signal Model
- **Application of Power System Stabilizers** **05 hrs.**
  Basic Concepts of PSS, Control Signals, Structure and tuning of PSS, Field Implementation, PSS Design and Applications, Resent Development and Future Trends
- **Multi Machine System** **07 hrs.**
  Simplified model, Improved model of the system for linear load, Inclusion of dynamics of load and SVC, introduction to analysis of large power system.
- **Transient And Voltage Stability** **10 hrs.**
  Definition, Equal area criteria, Numerical integration methods, Transient stability analysis, factors affecting voltage instability and collapse, analysis and comparison of angle and voltage stability, analysis and comparison voltage instability and collapse, control of voltage instability, Implication on power system dynamic performance.

Total Hours-45

Note: Tutorials will be conducted separately for 15 hours

3. **Books Recommended:**

1 K.R.Padiyar ,“Powerm System Dynamics Stability and Control”, Second Edition, B S Publication, 2008.
2 Prabha Kundur, “Power System Stability and, Tata McGraw Hill pub, 2006.
3 P.M.Anderson, A.A. Fouad,”Power System Control and Stability”, Second Edition, John Wiley and 2002.

4. **List of Experiments**

1 To study mathematical modeling of R-L-C and complex electrical circuits using MATLAB. 2.
2 To find the eigen values and eigen vectors of R-L-C circuits using state space analysis
3 To obtain the free response of a given system and understand the concepts of modes
4 . To observe variation of rotor angle and to find critical clearing time when fault occurs at:
(1) Sending end of the line
(2) Mid-point of the line
(3) When the fault at mid-point is cleared by removing the faulty line of SMIB system
5 To solve the swing equation by applying numerical method.
6 To simulate the SMIB system with different loading conditions using model 1.1 in MATLAB.
7 To design PSS using classical method for SMIB system.
8 To simulate Two area (4 machine, 10 bus) multimachine system using model.1.

M. Tech. Power System, Ist year, Semester II	
	L **T** **P** **Credit**
APPLICATIONS OF POWER ELECTRONICS IN POWER SYSTEMS (Core-V)	**3** **1** **2** **05**

EEPS104

1. **Course Outcomes (COs):**

At the end of the course, the students will be able to:

CO1	To evaluate compensator requirement for voltage regulation and load compensation.
CO2	To understand transmission line problems and their mitigation
CO3	To evaluate the effect of shunt controllers on operation of transmission line
CO4	To evaluate the effect of series controllers on operation of transmission line
CO5	To evaluate the effect of shunt-series controllers on operation of transmission line
CO6	To evaluate effectiveness of DVR.

2. **Syllabus**

- **Theory of Load Compensation** **05 hrs.**
  Requirement and objectives of load compensation, specification of load compensator, voltage regulation, shunt active filter for harmonics and reactive power compensation, relationship between variables in abc, alpha-beta and dq domain.
- **AC Transmission line and Reactive Power Compensation** **12 hrs.**
  Fundamentals of ac power transmission, transmission problems and needs, analysis of uncompensated AC line, Passive reactive power compensation, comparison between series and shunt capacitor compensation, Compensation by STATCOM and SSSC, Generalized equivalent circuit for FACTS controller with their control variables and constraint equations.
- **FACTS Controllers for Shunt Compensation** **11 hrs.**
  Variable Impedance type (SVC) & switching converter type (STATCOM) shunt controllers, their theory, configuration, characteristics, control and applications. Simulations of these controllers in PSCAD/MATLAB.
- **FACTS Controllers for Series Compensation** **12 hrs.**
  Variable Impedance type (TCSC) & switching converter type (SSSC) series controllers, their theory, configuration, characteristics, control and applications. Simulations of these controllers in PSCAD/MATLAB.
- **Unified Power Flow Controller (UPFC)** **07 hrs.**
  Theory, configuration, characteristics, control and applications of UPFC. Simulations of UPFC controllers in PSCAD/MATLAB.
- **Dynamic Voltage Restorer (DVR) and Unified Power Quality Conditioner (UPQC)** **07 hrs.**
  Theory, configuration, characteristics, control and applications of DVR and UPQC. Simulations of these controllers in PSCAD/MATLAB.

Total Hours-45

Note: Tutorials will be conducted separately for 15 hours

3. **<u>Books Recommended:</u>**

1. K.R.Padiyar ,"Powerm System Dynamics Stability and Control", Second Edition, B S Publication, 2008. FACTS controllers for transmission and Distribution system by K. R. Padiyar New Age international Publishers 1st edition -2007.
2. Understanding FACTS: Concepts and Technology of Flexible AC Transmission by N. G. Hingorani and Laszlo Gyugyi, IEEE Press, New York, 2000.
3. P.M. Reactive Power Control in Electric Systems by T. J. E. Miller, John Wiley & Sons, 1982
4. Flexible ac transmission systems (FACTS) by Song, Y.H. and Allan T. Johns, Institution of Electrical Engineers Press, London, 1999.
5. Thyristor based FACTS controllers for electrical transmission systems by Mathur R. M. and Verma R. K, IEEE press series on power engineering Wiley IEEE press, 2002.

4. **List of Experiments**

1 To verify calculation of load balancing in MATLAB simulink.

2 Verification of long line performance equations using MATLAB simulink.

3 Implementation of various PWM methods: SPWM, Selective harmonic elimination, space vector in simulink.

4 To verify relationship of variables in various domain such abc, alpha-beta and d-q.

5 Simulation of active filter for linear and non-linear loads.

6 Simulation of TCR and verify harmonic profile in both single phase and three phase system.

7 Simulation of TCSC for various modes.

8 Simulation of STATCOM.

9 Simulation of SSSC.

10 Simulation of UPFC.

M. Tech. Power System, Ist year, Semester II

HIGH VOLTAGE ENGINEERING & EHV AC TRANSMISSION (Elective III)

EEPS112

L	T	P	Credit
3	0	0	03

1. **Course Outcomes (COs):**

At the end of the course, the students will be able to:

CO1	To generate and measure High Voltage AC & DC, Impulse voltage & current.
CO2	To perform Non-destructive testing of insulation.
CO3	To design high voltage laboratory.
CO4	To determine line parameters, voltage gradient, corona loss, Radio noise, Electrostatic field of EHV AC transmission line.
CO5	To analyse voltage gradient, corona effects, Electrostatic field of EHV AC transmission line.

2. **Syllabus**

- **Generation of High Voltages** **08 hrs.**
  Generation of High DC Voltages: Half Wave and full wave circuits –Ripple voltages in HW and FW rectifiers. Simple and cascade voltage doubler. Crockroft Walton voltage multiplier circuits. Ripple and regulation. Electrostatic machines – principles – Van de Graff generator. Generation of high AC voltages: Cascade transformers, resonant transformers – parallel and series resonant test systems. Generation of high frequency high voltages – Tesla coil. Generation of impulse voltages – Standard impulse wave shape Basic circuits for producing impulse waves – Analysis of commercial impulse generator circuits – Wave shape control, multi-stage impulse generators – Marx circuit – modified Marx impulse generator circuit – Components of multi stage impulse generator. Generation of Switching surges. Generation of impulse current. Definition of impulse current waveform – Circuit for producing impulse current waves.
- **Measurements Of High Voltages & Currents** **05 hrs.**
  Measurement of high voltages and currents-DC, AC and impulse voltages and currents-DSO, electrostatic and peak voltmeters, sphere gaps-factors affecting measurements, potential dividers (capacitive and resistive)- series impedance ammeters, rogowski coils, hall effect generators.
- **Non-Destructive Testing of Insulation** **07 hrs.**
  Measurement of insulation resistance, polarization index, dielectric constant and loss factor. Partial Discharge Measurement, RI Measurement. HV Testing of various power apparatus, Condition monitoring of Electrical apparatus.
- **Design, Planning and Layout of HV Laboratory** **02 hrs.**
  Test Facilities, Activities & Studies in HV lab, Classification of hv lab, Size & rating of hv lab, grounding of impulse testing laboratories.
- **Introduction To EHV AC Transmission** **02 hrs.**
  Role of EHV AC transmission, standard transmission voltages, Average values of line parameters, power handling capacity and Line loss, surge impedance loading.
- **Calculation of Line and Ground Parameters** **06 hrs.**
  Resistance of conductors, Properties of bundle conductors, Inductance of EHV line configuration, Line capacitance calculation, Sequence inductance and capacitance, line parameters for Modes of propagation.

- **Voltage Gradients of Conductors** **06 hrs.**
  Field of sphere gap & line charges and their properties, charge potential relations for multi conductor lines, surface voltage gradient on conductors, gradient factors and their use, distribution of voltage gradient on sub conductors of bundle.
- **Corona And its Effects** **06 hrs.**
  Corona loss formulas, charge- voltage diagram and corona loss, Audible noise, limits for audible noise, AN measurement and meters, formula for audible noise and use in design, radio interference, limits of radio interference fields, CIGRE formula, measurement of RI, RIV and excitation function.
- **Electro Static Fields** **03 hrs.**
  Calculation of Electrostatic Field of AC Lines, Effect of High E.S. Field on Humans, Animals, and Plants.

Total Hours-45

3. <u>Books Recommended:</u>

1. M.S.Naidu, V. Kamaraju, “High voltage Engineering”, TMH, 4th edition, 2008.
2. Begamudre, “EHV AC Transmission engineering”, Wiley Easter Ltd. 4th Ed, 2011.
3. E,Kuffel, W.S.Zaengl, J.Kuffel, “ High voltage Engineering Fundamentals” , Newnes, 2nd edition, 2000.
4. EPRI, Palo Alto, “Transmission line reference book 345 KV & above”.

M. Tech. Power System, Ist year, Semester II

ELECTRIC VEHICLES TECHNOLOGY (Elective III)

L	T	P	Credit
3	0	0	03

EEPS114

1. **Course Outcomes (COs):**

At the end of the course, the students will be able to:

CO1	Understand the basic concepts of electric vehicles and popular traction systems.
CO2	Analyze the different propulsion unit and their working.
CO3	Understand the drive-train topologies and advanced propulsion techniques.
CO4	Analyze the various energy storage methodologies in traction systems.
CO5	Understanding the Energy Management in Electric Vehicle.

2. **Syllabus**

- **Conventional Vehicles** **09 hrs**

  Vehicle dynamics, Basics of vehicle performance, vehicle power source characterization, transmission characteristics and mathematical models to describe vehicle performance. Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drivetrains on energy supplies.
- **Hybrid Electric Drivetrains** **09 hrs.**

  Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Electric Drive-trains; Basic concept of electric traction, introduction to various electric drive-train topologies. Power flow control in electric drive-train topologies, efficiency analysis.
- **Electric Propulsion Unit** **09 hrs.**

  Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, Switch Reluctance Motor drives, drive system efficiency
- **Energy Storage** **09 hrs.**

  Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based, Fuel Cell based, Super Capacitor based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE) Sizing the propulsion motor, sizing the power electronics selecting the energy storage technology, Communications, supporting subsystems
- **Energy Management Issues** **09 hrs.**

  Classification and comparisons of different energy management strategies, implementation implementation issues of energy management strategies, Case Studies: Design of a Hybrid Electric Vehicle (HEY), Design of a Battery Electric Vehicle (BEV).

Total Hours-45

3. **Books Recommended:**

1. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 2014.
2. Iqbal Hussein Electric and Hybrid Vehicles: Design Fundamentals, CRC Pres, 2003.
3. Mehrdad Ehsani, Yi.mi Gao Sebastjan E. Gay, Ali Emadi, Modem Electric, Hybrid Electric and Fuel Cell Vehicles; Fundamentals Theory and Design, CRC Press 2004.
4 James Larminie John Lowry, Electric Vehicle Technology Explained , Wiley, 2003.

5 S. Onorio, L. Serrao and G. Rizzoni, 'Hybrid Electric Vehicles: Energy Management Strategies", Springer 2015.
6 T. Denton 'Electric a.ad Hybrid Vehicles' , Routledge 2016.

M. Tech. Power System, Ist year, Semester II

CRYPTOGRAPHY AND CYBER SECURITY (Elective III)

L	T	P	Credit
3	0	0	03

EEPS116

1. **Course Outcomes (Cos):**

At the end of the course, the students will be able to:

CO1	The students would be able to understand the concept of encryption and privacy issues and its significance in cyber security.
CO2	The students would be able to learn about cryptography and risk analysis using various terms and methods such as attack classification, ciphers, keys etc.
CO3	The students would able to learn the impact of bad data injection and identification for cyber security using encryption methods.
CO4	The students would be able to learn the use of cloud network for information storage for smart grids and its security. The Indian perspective will also be explored.
CO5	The privacy prevention and its methods would be learned for smart grids.
CO6	The students would be able to understand the management and legal concerns and rules/protocols for cyber security.

2. **Syllabus**

- **Introduction and Overview of the Security and Privacy Issues in electrical network** **04 hrs.**
  Security issues in smart grids, Physical network security, Information network security, Privacy issues in smart grids, Reliability in smart grid- preliminaries on reliability quantification, System adequacy quantification, Congestion prevention: An economic dispatch algorithm.
- **Cryptography for Cyber security** **08 hrs**.
  Introduction and Overview of Cryptography and security, Historical perspective, Threats, risks, consequences, Physical network security, Information network security, Sources of threats, Attacks classification, Preventive measures, remedial measures, Basics of cryptography: Confusion vs. diffusion, Stream ciphers vs. block ciphers, Keys and key management, Key exchange, Symmetric key cryptography vs asymmetric key cryptography, Cryptographic hash functions, Properties, Merkle Damgard construction, md family, sha family, Digital signatures , Public key encryption and Misc. techniques, Introduction, Public key crypto systems, RSA algorithm, Encryption using non-cryptographic tools, Authentication principles and methods, Passwords, two-factor authentication, One-way encryption
- **Bad Data Detection** **07 hrs.**
  Preliminaries on falsification detection algorithms, Autocorrelation function (ACF), Time series modeling of load power: Outline of the proposed methodology, Seasonality, Fitting the AR and MA models, Case study: Stabilizing the variance, Fitting the stationary signal, Model fine-tuning and evaluation.
- **Cloud Network Data Security in Smart Grid** **10 hrs.**
  Introduction, Service-level agreements, Live migration of a VM image in cloud computing: Data Migration, Network migration, Architecture and Solutions for: Application Manager, Site Broker, Hybrid cloud broker, Smart Meters and Smart Loads: The Advance Metering Infrastructure (AMI), AMI communication network, Hierarchical AMI communication network format, Internet-Protocol-

Based Mesh AMI communication network, Standardization of AMI:ANSI C12.22, IEC 62056, AMI and Distribution Management System Integration (DMI), Software Architecture and Evaluation of the MDI layer.

- **Privacy Preservation in Smart Grid** **08 hrs.**
  End- User Privacy: Introduction and Preliminaries to privacy preservation methods, K- Anonymity cloaking, Location obfuscation, Preliminary definitions, Privacy Preservation using location obfuscation methods, Preliminaries on Mobile nodes trajectory privacy, Location based services, Privacy preservation quantification: Probabilistic model, A vernoi-based location obfuscation method, Computing the instantaneous privacy level, concealing the movement path.
- **Management Aspects in Cyber Security** **08 hrs**
  System Administration policies, Security audit, Penetration testing and ethical hacking, Mandatory Access control, Discretionary Access Control, Monitoring and logging tools, Legal aspects.

Total Hours-45

3. Books Recommended:

1. Smart Grids: Security and Privacy Issues, Kianoosh G. Boroojeni, M.Hadi Amini, S.S. Iyengar, Springer, 2017.
2. Set Security and Privacy in Smart Grids, Yang Xiao, CRC Press Taylor & Francis Group, 2014.
3. Applied Cyber Security and the Smart Grid, E.D Knapp, Raj Samani, Elsevier-SYNGRESS.

4

5 AtulKahate – Cryptography and Network Security , 2nd Edition Tata McGraw Hill Publication, New Delhi-2006.

6 Behrouz A. Forouzan and D. Mukhopadhyay- Cryptography & Network Security, 2nd Edition - 1st reprint 2010, McGraw Hill, New Delhi.

7 Wade Trapple, Lawrence C. Washington- Introduction to Cryptography with coding Theory, 2nd Edition pearson Education.

8 Alfred J. Menezes, Paul C. van Oorschot and Scott A. Vanstone , Hand- book of Applied Cryptography, CRC Press.

9 Margaret Cozzens, Steven J Miller, The mathematics of encryption, American Mathematical Society.

M. Tech. Power System, Ist year, Semester II

ADVANCE POWER CONVERTERS FOR RENEWABLE ENERGY APPLICATIONS (Elective III)

L	T	P	Credit
3	0	0	03

EEPS118

1. **Course Outcomes (COs):**

At the end of the course, the students will be able to:

CO1	Analyze and understand power converter interfaced solar PV systems.
CO2	Select and design passive filters for grid-connected solar and wind systems.
CO3	Analyze and understand converter topologies for solar PV systems.
CO4	Analyze and understand converter topologies for wind turbine systems.
CO5	Design and analyze converter control for solar and wind turbine systems.

2. **Syllabus**

1. Power Converters for Solar PV Systems **18 hrs**

- **PV system classifications, requirements, and challenges**
  Standalone, grid-feeding and hybrid PV systems, Grid-feeding inverters: central, string and micro-Inverters, single-stage and two-stage inverter configurations, Grid requirements for PV, DC and AC side filtering requirements and design, issue of leakage/residual current and remedial techniques, Control structure: MPPT and grid-current control.
- **PV inverters derived from H-bridge topology**
  Basic full-bridge inverter, H5 inverter (SMA), HERIC inverter, REFU inverter, full-bridge inverter with DC Bypass (FB – DCBP), full-bridge Zero Voltage Rectifier (FB – ZVR)
- **High Voltage-Gain DC-DC Converters**
  Magnetic coupling based isolated/non-isolated converters, voltage multiplier cell, switched inductor and switched capacitor based converters, voltage lift converters, Z-source and resonant converters
- **PV Power Control**
  Grid Synchronization and PLL, MPPT & grid current control with above mentioned converters.

2. Power Converters for Wind Turbine (WT) Systems **20 hrs**

- **WT system classifications and requirements**
  Power conversion structures for variable speed wind turbine systems with IG, DFIG and PMSM; Grid requirements for WT systems, Conventional unidirectional and bi-directional power converters for WT systems.
- **Multilevel Power Converters**
  Three-Level Neutral-Point Diode Clamped Back-To-Back Topology (3L-NPC BTB), Three-Level H-Bridge Back-to-Back Topology (3L-HB BTB), Five-Level H-Bridge Back-to-Back Topology (5L-HB BTB), Three-Level Neutral-Point Diode Clamped Topology for Generator Side and Five-Level H-Bridge Topology for Grid Side (3L-NPC + 5L-HB).
- **Introduction to Matrix Converters:**
  Principle of operation, various configurations and applications.
- **Multi-input DC-DC Converters for Renewable Applications** **07 hrs**
  Various multi-input DC-DC converter topologies, their operations and applications

Total hours-45

3. References:

1. Remus Teodorescu et al, ``Grid converters for photovoltaic and wind power systems'', John Willey & Sons Ltd., 2011.
2. Sudipta Chakraborty et al, ``Power Electronics for Renewable and Distributed Energy Systems: A Sourcebook of Topologies, Control and Integration'', Springer Science & Business, 2013.
3. Ashok L. Kumar et al,`` Power electronic converters for solar photovoltaic systems'', Academic Press, 2020.
4. Nicola Femi et al, ``Power Electronics and control for maximum Energy Harvesting in Photovoltaic Systems'', CRC Press, 2013.

M. Tech. Power System, Ist year, Semester II	**L**	**T**	**P**	**Credit**
INSULATION ENGINEERING (Elective III)	**3**	**0**	**0**	**03**

EEPS120

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	To describe the electrical insulation systems.
CO2	To illustrate Breakdown mechanisms in insulation.
CO3	To explain nano-dielectrics, multi stress aging, space charge.
CO4	To analyse Stochastic models of breakdown.
CO5	To design insulation systems.

2. Syllabus

- **Introduction** **06 hrs.**
  Dielectrics and electrical insulation systems used in high voltage power apparatus: gaseous, vacuum, liquid, solid and composite insulation, Behaviour of electrical insulation under electric stress.
- **Breakdown mechanisms in gaseous insulation** **04 hrs.**
  Ionization, attachment, Townsend and streamer theories, Paschen's law, partial breakdown, corona, time lags in breakdown, breakdown under impulse voltages, volt-time characteristics of breakdown,
- **Breakdown in vacuum** **03 hrs.**
- **Breakdown in liquid insulation** **03 hrs.**
- **Breakdown in solid and composite insulation** **04 hrs.**
- **Introduction to Nano dielectrics** **03 hrs.**
- **Space charge in dielectrics** **02 hrs.**
- **Electrical degradation** – treeing, partial discharge, tracking & erosion. **04 hrs.**
- **Stochastic models of breakdown** **05 hrs.**
- **Multi-stress ageing** **03 hrs.**
- **Design of insulation systems** used in various power apparatus (case studies) **08 hrs.**

Total Hours-45

3. References:

1. E.Kuffel, W.S.Zaengl, J.Kuffel, " High voltage Engineering Fundamentals" , Newnes, 2nd edition,2000.
2. M.S.Naidu, V. Kamaraju, "High voltage Engineering", TMH, 4th edition, 2009.
3. C L Wadhwa, "High voltage Engineering", New age International, 4th edition, 2021.
4. C L Wadhwa, "High voltage Engineering", New age International, 4th edition, 2021.

M. Tech. Power System, Ist year, Semester II

L	T	P	Credit
3	0	0	03

RENEWABLE ENERGY SOURCES (Elective IV)

EEPS142

1. **Course Outcomes (COs):**

At the end of the course, the students will be able to:

CO1	Explain the need of Renewable energy.
CO2	Analyze the different forms renewable energy sources
CO3	Explain principle and construction different renewable energy plants
CO4	Estimate the performance and efficiency of the different renewable energy sources plant.
CO5	Identify the applications of renewable energy sources
CO6	Select the appropriate location for harnessing renewable energy

2. **Syllabus**

- **wind Energy** **10 hrs.**

  Introduction to wind energy – basic principles of wind energy – conversion – power in the wind – maximum power – forces on the blade – wind energy conversion – small producers and large producers – wind data and (qualitative treatment only) energy estimation – site selection consideration – Basic components of wind energy conversion systems – classifications of WECS – advantages and disadvantages of WECS – generating system – scheme of electric generation – generator control - load control – energy storage – applications of wind energy – inter connecting system – environmental aspects – safety systems – prospects.

- **Solar Energy** **16 hrs.**

  Solar electric power generation – Principles of solar cells – semiconductor junctions – Conversion efficiency and power output – Photovoltaic system for power generation – Solar cell connecting arrangements – storage batteries – Inverters – applications of solar PV system.
  SOLAR THERMAL ENERGY: Introduction, Solar Thermal devices, Solar Pond. Solar thermal electric conversion.

- **Fuel Cells and Hydrogen Energy** **05 hrs**

  FUEL CELLS: Introduction –Types-Characteristics –Applications
  HYDROGEN ENERGY: Introduction –Production -Characteristics –Storage –Applications

- **Biomass Energy** **07 hrs**

  Introduction to biomass – Biomass conversion classification of biogas plants –Types of Biogas Plants Biogas from plant wastes – Community biogas plants – Materials used for biogas generation – selection of site for biogas plant –Fuel properties of biogas – utilization of biogas – methods of obtaining energy from Biomass Combustion.

- **Other Source of Energy** **07 hrs**

  GEOTHERMAL ENERGY: Introduction to Geothermal Energy –prime movers for Geothermal Energy conversion – classifications– Applications of Geothermal Energy at different temperatures - Geothermal Energy in India – prospects.
  OCEAN ENERGY :Introduction – Tidal Energy, Wave Energy, OTEC, Energy conversion to Electrical form - Characteristics –Applications
  MICRO HYDROPOWER: Introduction –Types- working- Characteristics –Applications

Total Hours-45

3. **Books Recommended:**

1 S. P. Sukhatme, “Solar Energy - Principles of thermal collection and storage”, TMH, 2008.
2 Thomas Ackermann, “Wind Power in Power System”, John Willey &Sons, 2005.
3 J. Twidell and T. Weir, “Renewable Energy Resources”, E & F N Spon Ltd, London, 1999.
4. Daniel, Hunt V, "Wind Power - A Handbook of WECS", Van Nostrend Co., New York, 1981.
5. Gary L. Johnson, "Wind Energy Systems", Prentice Hall Inc., 1985.

M. Tech. Power System, I^st year, Semester II

	L	T	P	Credit
HVDC TRANSMISSION (Elective IV)	**3**	**0**	**0**	**03**

EEPS144

1. **Course Outcomes (COs):**

At the end of the course, the students will be able to:

CO1	To explain the configurations, advantages and applications of HVDC Transmission.
CO2	To analyse the operation of HVDC converters.
CO3	To analyse HVDC control methods for power flow.
CO4	To calculate the harmonics and filters parameters.
CO5	To analyse the Faults in HVDC System and their Protection.
CO6	To explain the Parallel Operation of AC-DC Systems.

2. **Syllabus**

- **Introduction to HVDC** **04 hrs.**
  Historical development in DC Transmission, Advantages & Disadvantages of DC Transmission over Ac Transmission, DC Transmission Systems: Mono-polar, bi-polar and homo-polar lines, back-to-back HVDC systems, Components of HDVC Transmission System, classification, Main applications of DC Transmission
- **Converter Operation** **11 hrs.**
  Choice of converter configuration, 6-pulse and 12-pulse rectifiers and inverters; Equivalent circuits of rectifier and inverter, relations between ac and dc quantities.
- **Converter charts** **04 hrs.**
  Charts with dc voltage and current as rectangular coordinates, charts with active and reactive powers as rectangular coordinates and their relation.
- **HVDC control systems** **06 hrs.**
  Constant current control, constant excitation angle control, VDCOL, constant ignition angle control, Individual phase control and equidistant pulse control; Valve blocking and by-passing; Starting, stopping and power flow reversal, advanced controller.
- **Harmonics and Filters** **06 hrs**.
  Characteristic and non-characteristic harmonics, input harmonics, output harmonics, problems due to harmonics, ac and dc filters.
- **Faults in HVDC system and their protection** **04 hrs.**
  DC line faults, clearing line faults, converter faults, ac system faults, rectifier side and inverter side faults; DC circuit breakers, overvoltage protection.
- **Parallel Operation of AC-DC Systems** **04 hrs.**
  Influence of ac system strength on ac-dc interaction, effective short-circuit ratio (ESCR), problems with low ESCR systems
- **Recent Developments in HVDC Transmission** **06 hrs.**
  Problems encountered with classical (CSC based) HDVC Transmission Systems and their overcome by VSC based HVDC systems, Operation Principle and control of VSC Based HVDC Transmission, VSC-HVDC Under AC and DC Fault Conditions.

Total Hours-45

3. **Books Recommended:**

1 E. Kimbark, Direct Current Transmission by Wiley International New York, 1971.
2 K.R. Padiyar, HVDC Power Transmission System, New Age International Private Limited, 2008.
3 E.Ulmann, Power Transmission by Direct Current, Springer-Verlag, 1975
4. P. Kundur, Power System stability and control, Tata McGraw Hill education, 1994.
5. J. Arrillaga, High Voltage Direct Current Transmission, IEE Power Engineering series, London, 1998
6. J. Arrillaga, Y. H. Liu and N. R. Watson, Flexible Power Transmission: The HVDC Option, John Wiley and Sons, New York, 2007
7. Nagwa F. Ibrahim and Sobhy S. Dessouky,Design and Implementation of Voltage Source Converters in HVDC Systems,Springer Nature, Switzerland,2021.
8. Chan-Ki Kim,Vijay K. Sood,Gil-Soo Jang,Seong-Joo Lim and Seok-Jin Lee, HVDC Transmission Power Conversion Applications in Power Systems, John Wiley & Sons,Singapore,2009.

M. Tech. Power System, I[st] year, Semester II	L	T	P	Credit
ENERGY AUDIT (Elective IV)	**3**	**0**	**0**	**03**
EEPS146				

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Explain the basics of energy audit methodology.
CO2	Classify different energy audit methodologies.
CO3	Analyze various electrical load management techniques
CO4	Perform the energy audit of motors and lighting systems
CO5	Asses the energy saving in different buildings
CO6	Use various software tools for energy audit studies

2. Syllabus

- **Global and Indian Energy Scenarios** **6 hrs.**
  Energy Scenario of India, Energy Strategy for the Future, basics of Energy Audit, Equipment required for Energy Audit: Electrical Measurement, Thermal Measurement, Light Measurement, Speed Measurement, Data Logger and Data-Acquisition System.
- **Types of Energy Audits and Energy-Audit Methodology** **12 hrs.**
  Definition of Energy Audit, Energy-Audit Methodology: Audit Preparation, Execution, Reporting. Financial Analysis, Sensitivity Analysis, Project-Financing Options, Energy Monitoring and Targeting.
- **Electrical-Load management** **6 hrs.**
  Electrical Basics, Electrical Load Management, Variable-Frequency Drives, Harmonics and Its Effects, Electricity Tariff for residential and commercial loads, Power Factor, Transmission and Distribution Losses.
- **Energy Audit of motors** **6 hrs.**
  Parameters Related to Motors, Efficiency of a motor, Energy conservation in motors, BEE Star Rating and Labelling
- **Energy Audit of Lighting Systems** **6 hrs**.
  Fundamentals of Lighting, Different Lighting Systems, Fixtures (Luminaries), Reflectors, Lenses and Louvers, Lighting Control Systems, Lighting System Audit, Energy-Saving Opportunities
- **Energy Audit Apllied to Buildings** **9 hrs.**
  Energy-Saving Measures in New Buildings, Water Audit, Audit Your Home, General Energy-saving Tips Applicable to New as Well as Existing Buildings, Introduction to Computer Software and Formats for Energy Audit.

Total Hours-45

3. Books Recommended:

1 Sonal Desai, “Handbook of Energy Audit”, 1st Edition, Tata McGraw Hill, 2015.
2 K V Sharma & P Venkataseshaiah, “Energy Management and Conservation”, 1st Edition, International Publishing House pvt.ltd, 2011.
3 Wayne C. Turner, Steve Doty, “Energy Management Handbook”, 6th Edition, CRC Press.
4 Murphy, W. R.,G McKay, “Energy Management”, Elsevier, 2007

M. Tech. Power System, I^st year, Semester II

ADVANCED ENERGY STORAGE DEVICES AND APPLICATIONS (Elective IV)

L	T	P	Credit
3	0	0	03

EEPS148

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Describe different energy storage technology and compare them based on their performance
CO2	Modelling of various electrochemical storage devices and develop suitable battery management system
CO3	Discuss electrical and magnetic storage systems and describe hydrogen and fuel cells
CO4	Detailed understanding of thermal and mechanical storage and analyze energy savings
CO5	Explain and illustrate hydrogen and fuel cells
CO6	Describe different energy storage technology and compare them based on their performance

2. Syllabus

- **Introduction to energy storage** **5 hrs.**
  Relevance and scenario, perspective on development of energy storage systems, energy storage criteria, general concepts, fundamentals and applications, energy storage technologies, future prospect of storage, Ragone plots
- **Electrochemical energy storage** **10 hrs.**
  Battery technologies and different battery chemistry, electrode materials, electrolytes. performance comparison, reaction mechanism, practical parameters, technical characteristics, equivalent circuit. Testing, standards and system sizing, battery storage integration.
- **Battery management system (bms)** **10 hrs.**
  BMS functionality, requirements; State Estimation: definitions and their estimation methods; SOH estimation: predictive SOH models, aging, capacity estimation, self-discharge detection, parameter estimation, remaining useful life estimation; Cell balancing: causes of imbalancing, balancing strategies, charge transfer balancing-design choices, circuits for balancing; thermal management of battery; case study
- **Electrical and magnetic storage systems** **8 hrs.**
  Supercapacitors: basics, technical characteristics, equivalent circuit, electrode material, pseudocapacitive energy storage, energy storage devices, applications and challenges; Magnetic Systems- energy storage in superconducting magnetic systems, superconductive materials, applications.
- **Fuel cells and hydrogen storage** **06 hrs**
  Fuel cell: working, basic components, principle, thermodynamics of fuel cell, types, challenges; Hydrogen storage-hydrogen as an energy vector and basic principles, hydrogen production, strategies for storing energy in hydrogen, applications.
- **Thermal and mechanical storage** **06 hrs**
  Basic principle, criteria for TES evaluation, operating characteristics, standards, phase change materials, sensible TES- passive and active systems, design and thermal stratification, energy and exergy analyses, efficiency measures. Mechanical storage: flywheel, pumped hydropower storage and compressed-air energy storage, comparison and application, principle of operation, function and deployments; case study

Total Hours-45

3. Books Recommended:

1 1. Robert A. Huggins, “Energy storage”, Springer Nature, 2nd edition, 2016.

2 Christopher D. Rahn, and Chao-Yang Wang, “Battery systems engineering”, John Wiley & Sons, 2013.

3 Ibrahim Dincer, and Marc A. Rosen, “Thermal energy storage: systems and applications” John Wiley & Sons, 3rd edition, 2021

4 Gregory L. Plett, “Battery management systems, Volume II: Equivalent-circuit methods”, Artech House, 2015.

5 Phil Weicker, “A systems approach to lithium-ion battery management”, Artech house, 2013.

6 F. Barnes and J. Levine. "Large energy storage systems", CRC press, 2011.

M. Tech. Power System, Ist year, Semester II

WIDE AREA POWER SYSTEM CONTROL (Elective IV)

EEPS150

L	T	P	Credit
3	0	0	03

1. **Course Outcomes (COs):**

At the end of the course, the students will be able to:

CO1	Explain various Synchrophasor Measurement Techniques
CO2	Implement and test wide area measurement systems
CO3	Realize optimal placement of PMU and state estimation using PMU data
CO4	Monitor, analyse and control power system conditions in real time
CO5	Interpret wide area PMU measurements
CO6	At the end of the course, the students will be able to:

2. **Syllabus**

- **PHASOR MEASUREMENT TECHNIQUES** **12 hrs.**
  Phasor Measurement Techniques: Basic Concepts and Definitions SCADA vs PMU, Synchrophasors, Frequency, and ROCOF, Steady-State and Dynamic Conditions in Power Systems, Classical Phasor Versus Dynamic Phasor, Basic Definitions of Accuracy Indexes, Algorithms for Synchrophasors, Frequency, and ROCOF, Methods to Calculate Synchrophasors based on a Steady-State Model and Dynamic Signal Model, Evaluation of Frequency and ROCOF, Dynamic Behavior of Phasor Measurement Algorithms.

- **PHASOR MEASUREMENT UNITS AND PHASOR DATA CONCENTRATORS** **10 hrs**
  Phasor measurement units and Phasor data concentrators: WAMS architecture, Sensors for PMUs, International Standards for Instrument Transformers, Accuracy of Instrument Transformers, Transducer Impact on PMU Accuracy, Hardware for PMU and PMU Integration, PMU Architecture, Data Acquisition System, Synchronization Sources, Communication and Data Collector, Distributed PMU, International Standards for PMU and Tests for Compliance, IEC 61850.

- **STATE ESTIMATION** **12 hrs.**
  State Estimation and PMUs: Formulation of the SE Problem, Network Observability-SE Measurement Model, SE Classification, State estimation with phasor measurents, Linear state estimation, Dynamic estimators. Optimal PMU placement, meta-heuristic and deterministic algorithms, Integer Linear Programming Technique.

- **WIDE AREA MONITERING SYSTEM** **11 hrs.**
  WAMS applications- real-time analysis and technologies to detect, locate and characterize power system disturbances, monitoring power system oscillatory dynamics- Interpretation and visualization of wide-area PMU measurements, power system control with phasor feedback, discrete event control.

Total Hours-45

3. **Books Recommended:**

1. Antonello Monti, Carlo Muscas, Ferdinanda Ponci, Phasor Measurement Units and Wide Area Monitoring Systems, Academic Press, 2016.
2. A.G. Phadke, J.S. Thorp, Synchronized Phasor Measurement and Their Applications, Springer 2008.
3. Yong Li, Dechang Yang, Fang Liu, Yijia Cao, Christian Rehtanz, Interconnected Power Systems: Wide-Area Dynamic Monitoring and Control Applications, Springer, 2015.
4. Ali Abur, Antonio Gómez Expósito, Power System State Estimation: Theory and Implementation, CRC Press, 2004.
5. Ma J., Makarov Y., Dong Z, Phasor Measurement Unit and its Applications on Modern Power Systems, Springer, 2010.

M. Tech. Power System, Ist year, Semester II

ADVANCED OPTIMIZATION METHODS

EEPS172

L	T	P	Credit
3	0	0	03

1. **Course Outcomes (COs):**

At the end of the course, the students will be able to:

CO1	Explain the basic principle of optimization.
CO2	Derive the equations and solution through linear programming method.
CO3	Estimate the performance of traditional optimization method.
CO4	Analyse the performance of constrained optimization algorithms.
CO5	Analyse the induction of non-traditional optimization algorithms.
CO6	Apply the optimization method in real world.

2. **Syllabus**

- **Introduction** **04 hrs.**
  Historical Development, Engineering application of Optimization, Formulation of design problems, Classification of optimization problems.
- **Linear programming** **08 hrs.**
  Theorem of Linear programming problems and Relation to convexity, Simplex method, Revised simplex method, Duality in linear programming(LP), Sensitivity analysis, other algorithms for solving LP problems.
- **Single and Multivariable Optimization** **09 hrs.**
  Single variable: Optimality criteria, Bracketing Methods, Region Elimination Method, Gradient Based methods: Newton-Raphson Method, Bisection Method, Secant Method; Multivariable: Optimality criteria, Direct Search Methods, Gradient Based Methods: Steepest Descent Method, Conjugate Gradient Method, Quasi-Newton Method, Variable Metric Method, applications.
- **Constrained Optimization Techniques** **08 hrs.**
  Characteristics of a constrained problem, Variable Elimination Method, Lagrange Multiplier, Kuhn-Tucker Conditions, Frank-Wolfe Method, Cutting plane Method, penalty function Methods, application.
- **Advanced Optimization Techniques** **16 hrs**.
  Introduction to Multi objective Optimization, Swarm intelligences, Genetic Algorithm, Teaching Learning Based Optimization, Rao algorithms and other Non-traditional Optimization Algorithms, applications.

Total Hours-45

3. **Books Recommended:**

1 S. S. Rao, ‘Engineering “Optimization theory and applications”, Fourth Edition, John Wiley and Sons, 2009.

2 Kalyanmoy Deb, “Optimization for Engineering Design: Algorithms and Examples” Prentice-Hall of India Pvt.Ltd.,2005

3 M.S. Bazaraa, H.D. Sheraliand C.Shetty, “Nonlinear Programming, Theory and Algorithms”, John Wiley and Sons, New York, 1993

4. Ke-Lin Du and M.N.S. Swamy, “Search and Optimization by Metaheuristics Techniques and Algorithms Inspired by Nature,” Springer International Publishing Switzerland, 2016

5. R. Venkata Rao, Teaching Learning Based Optimization Algorithm and Its Engineering Applications, Springer International Publishing Switzerland, 2016
6. Kwang Y. Lee and Mohamed and A. El-Sharkawi, Modern Heuristic Optimization Techniques Theory and Applications To Power Systems, John Wiley & Sons, Inc., Hoboken, New Jersey, 2008
7. Gang Lei, Jianguo Zhu and Youguang Guo, “Multidisciplinary Design Optimization Methods for Electrical Machines and Drive Systems,” Springer-Verlag Berlin Heidelberg 2016
8. Rangrajan K. Sundaram, “A First Course in Optimization Theory”, Cambridge University Press,1996
9. A.Ravindran, K.M. Ragsdell, G.V. Reklaitis, “Engineering Optimization Methods and Applications”, Wiley India Pvt.Ltd., 2006
10. E.S. Gopi, “Algorithm Collections for Digital Signal Processing Applications Using MATLAB,” Springer, Dordrecht, The Netherlands,2007

M. Tech. Power System, Ist year, Semester II

ADVANCED NUMERICAL METHODS

EEPS174

L	T	P	Credit
3	0	0	03

1. **Course Outcomes (COs):**

At the end of the course, the students will be able to:

CO1	Learn various advanced numerical methods.
CO2	Apply the numerical methods for solving problems related to electrical engineering.
CO3	Modeling various systems and perform regression analysis.
CO4	Analyse the convergence rate and stability of the algorithms
CO5	Select a suitable numerical method for solving the real time problems based on the accuracy, speed and stability.

2. **Syllabus**

- **Error Analysis** **04 hrs.**
  propagation of error, fixed point and floating-point algorithms, reminder theorem
- **Solution Of System of Nonlinear Equations** **06 hrs.**
  Newton-Raphson method, Method of Successive approximation, Adomian decomposition method, convergence criterion
- **Regression Analysis** **12 hrs.**
  Least Square criterion (LSq), two-dimensional regression for linear and nonlinear systems, multi-dimensional regression for linear and nonlinear systems
- **Solution To Ordinary Differential Equations** **12 hrs.**
  Single-step and multi-step explicit integration algorithms – Adam's Bashforth formula, multi-step implicit integration algorithms – Adam's Moulton formula, stability analysis.
- **Solution To Partial Differential Equations** **06 hrs.**
  Specification of initial and boundary conditions, Solution by finite difference method
- **introduction to integral equations** **05 hrs.**
  Homogenous and non-homogenous integral equations, numerical methods to solve solution to integral equations

Total Hours-45

3. **Books Recommended:**

1 Shastri S. S., "Introductory Methods of Numerical Analysis", Prentice Hall Ltd., 4th Edition, 2005.
2 Jain M. K., Iyengar S.R.K., Jain R.K., "Numerical Methods for Scientific and Engineering Computation", 4th Edition, 2003, New Age international Publishers, Pvt. Ltd.
3. S. D. Conte and Carl de Boor, Elementary Numerical Analysis an Algorithmic Approach, 3rd Edition, McGraw- Hill, 1980.
4. Pallab Ghosh, "Numerical Methods with Computer Programs", in C++, Printice Hall of India Private Ltd., 2006.
5. Teukolsky S. A., Vetterling W. T., Press W. H. & Flannery B. P., "Numerical recipes in 'C', 2nd Edition,
6. Leon O. Chua and Pen-Min Lin, "Computer-Aided Analysis of Electronic Circuits", Printice Hall Series in Electrical and Computer Engineering

M. Tech. Power System, Ist year, Semester II

L	T	P	Credit
3	0	0	03

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

EEPS176

1. **Course Outcomes (COs):**

At the end of the course, the students will be able to:

CO1	Explain the fundamental issues and challenges of Artificial Intelligence.
CO2	Analyze various Machine learning algorithms.
CO3	Compare machine learning/artificial intelligence approaches.
CO4	Apply various Machine learning methods.
CO5	Develop ANN/FL algorithms and models.
CO6	Implement various machine learning algorithms in real-world applications.

2. **Syllabus**

- **Introduction to Machine learning (ML)** **10 hrs.**
  Identification in the Limit, Oracle Based Learning, Probably Approximately Correct (PAC) Model, Boosting Bayesian Learning: Maximum Likelihood, Estimates, Parameter Estimation. Types of Machine learning – Basic Concepts in Machine Learning - SUPERVISED LEARNING: Linear Models for Classification: Discriminant Functions - Probabilistic Generative Models - Probabilistic Discriminative Models - Bayesian Logistic Regression, linear models, Logistic Regression, Generalized Linear Models, Unsupervised learning, clustering: K-means/Kernel K-means, Dimensionality, Reduction: PCA and kernel PCA, Evaluating Machine Learning algorithms and Model Selection, Ensemble Methods (Boosting, Bagging, Random Forests), Modelling Sequence /Time- Series Data, Deep Learning and Feature Representation, Learning, Scalable Machine Learning (Online and Distributed Learning)
- **Introduction to Artificial intelligence (AI)** **10 hrs.**
  Computerized reasoning – Artificial Intelligence (AI) – characteristics of an AI problem – Problem representation in AI – State space representation – problem reduction, Concept of small talk programming, Knowledge representation issues, predicate logic- logic programming, semantic nets-frames and
  inheritance, constraint propagation, representing knowledge using rules, rules based deduction systems, Reasoning under uncertainty, review of probability, Baye's probabilistic interferences and Dempster Shafer theory.
- **Artificial Neural Networks (ANN)** **10 hrs.**
  Feed forward Network Functions - Error Backpropagation -Regularization in Neural Networks – Mixture Density Networks – Bayesian Neural Networks. Kernel Methods – Dual Representations – Radial Basis Function Networks – Ensemble learning: Boosting – Bagging. Forecasting models using ANN, Trend analysis, Cyclical and Seasonal analysis, smoothing; Moving averages; Box-Jenkins, Holt-winters, Auto-correlation; ARIMA, Examples: Applications of Time Series in financial markets.
- **Fuzzy logic** **7 hrs.**
  Reasoning in uncertain environments, Fuzzy logic, fuzzy composition relation, operations on fuzzy sets, fuzzification - defuzzification, fuzzy decision making, fuzzy logic controllers, Fuzzy

Classification: Classification by equivalence relations-crisp relations, Fuzzy relations, Cluster analysis, Cluster validity, C-Means clustering, Hard C-Means clustering, Fuzzy C-Means algorithm, Classification metric, Hardening the Fuzzy C-Partition.

- **Application** **8 hrs**.
  Examples of Machine Learning Applications – Linear Models for Regression – Linear Basis Function Models – The Bias-Variance Decomposition – Bayesian Linear Regression – Bayesian Model Comparison. Radar for target detection, Deep Learning Automated ECG Noise Detection and Classification, ML in Network for routing, traffic prediction and classification, Application of ML in Cognitive Radio Network (CRN).

Total Hours-45

3. Books Recommended:

1 Timothy J.Ross - Fuzzy logic with engineering applications, 3rd edition, Wiley,2010.
2 George J.KlirBo Yuan - Fuzzy sets and Fuzzy logic theory and Applications, PHI, New Delhi,1995
3 Applied Machine Learning, M. Gopal, McGraw Hill Education
4. Machine Learning March 1997, Thomas M. Mitchell, McGraw-Hill, Inc. 2. Neural Networks: A Comprehensive Foundation, Simon Haykin, Prentice Hall
5. Neural Network Design, M. T. Hagan, H. B. Demuth, Mark Beale, Thomson Learning, Vikash Publishing House
6. Patrick Henry Winston, “Artificial Intelligence”, Addison Wesley, 2000.
7. Luger George F and Stubblefield William A, “Artificial Intelligence: Structures and Strategies for Complex Problem Solving”, Pearson Education, 2002.
8. Christopher Bishop, “Pattern Recognition and Machine Learning” Springer, 2007.
9. Kevin P. Murphy, “Machine Learning: A Probabilistic Perspective”, MIT Press, 2012.
10. Ethem Alpaydin, “Introduction to Machine Learning”, MIT Press, 3rd Edition, 2014
11. Sayed, A.H., 2014. Adaptation, learning, and optimization over networks. Foundations and Trends” in Machine Learning, 7(4-5), pp.311-801.

M. Tech. Power System, Ist year, Semester II

RELIABILITY EVALUATION OF ELECTRICAL SYSTEMS

EEPS178

L	T	P	Credit
3	0	0	03

1. **Course Outcomes (COs):**

At the end of the course, the students will be able to:

CO1	The students would be able understand the basic of reliability and its importance for electrical network.
CO2	The students would be able to implement and model for reliability evaluation of generating systems for LOLE and reliability indices.
CO3	The students would be able to calculate the duration and frequency of outages and availability from reliability.
CO4	The students would be able to evaluate the impact of interconnections on reliability.
CO5	The students would be able to extend the concept of reliability for electrical distribution network for its secure and safe operation with relays, circuit breakers, switches etc.
CO6	The Monte Carlo simulation concept would be implemented for electrical networks for verification and execution of reliability indices.

2. **Syllabus**

- **Introduction** **04 hrs.**
  Background, types of systems, qualitative and quantitative assessment and its uses, reliability definition and criteria, reliability indices, reliability evaluation techniques, reliability economics, data, monitoring and growth, Probabilistic reliability criteria for electrical network, Statistical and probabilistic measures, Absolute and relative measures, Methods of assessment, Concepts of adequacy and security, System analysis, Reliability cost and reliability worth Concepts of data
- **Generating capacity-basic probability methods** **08 hrs.**
  Introduction, The generation system model, Generating unit unavailability, Capacity outage probability tables, Comparison of deterministic and probabilistic criteria, A recursive algorithm for capacity model building, Recursive algorithm for unit removal, Alternative model-building techniques, Loss of load indices, Concepts and evaluation techniques, Numerica1 examples, Equivalent forced outage rate, Capacity expansion analysis, Evaluation techniques, Perturbation effects, Scheduled outages, Evaluation methods on period bases, Load forecast uncertainty, Forced outage rate uncertainty, Exact method, Approximate method, Application, LOLE computation, Additional considerations, Loss of energy indices, Evaluation of energy indices, Expected energy not supplied, Energy-limited systems, Practical system studies, Conclusions, Problems
- **Generating capacity-frequency and duration method** **08 hrs.**
  Introduction, The generation model, Fundamental development, Recursive algorithm for capacity model building, System risk indices, Individual state load model, Cumulative state load model, Practical system studies, Base case study, System expansion studies, Load forecast uncertainty, Conclusions, Problems.
- **Interconnected systems** **08 hrs.**
  Introduction, Probability array method in two interconnected systems, Concepts , Evaluation techniques, Equivalent assisting unit approach to two interconnected systems, Factors affecting the

emergency assistance available through the interconnections, Introduction, Effect of tie capacity, Effect of tie line reliability, Effect of number of tie lines, Effect of tie-capacity uncertainty, Effect of interconnection agreements, Effect of load forecast uncertainty, Variable reserve versus maximum peak load reserve, Reliability evaluation in three interconnected systems, Direct assistance from two systems, Indirect assistance from two systems, Multi-connected systems.

- **Distribution systems-basic techniques and radial networks** 10 **hrs**.
  Introduction, Evaluation techniques, Additional interruption indices, Concepts, Customer-orientated indices, Load- and energy-orientated indices, System performance, System prediction, Application to radial systems, Effect of lateral distributor protection, Effect of disconnects, Effect of protection failures, Effect of transferring loads, No restrictions on transfer, Transfer restrictions, Probability distributions of reliability indices, Concepts, Failure rate, Restoration times, conclusions, problems.
- **Applications of Monte Carlo simulation** **07 hrs.**
  Introduction, Types of simulation, Concepts of simulation, Random numbers, Simulation output, Application to generation capacity reliability evaluation, Introduction, Modelling concepts , LOLE assessment with non-chronological load, LOLE assessment with chronological load, Reliability assessment with non-chronological load, Reliability assessment with chronological load, Application, to distribution systems, Introduction, Modelling concepts, Numerical examples for radial networks, Numerical examples for meshed (parallel) networks, Extensions to the basic approach, Conclusions, Problems.

Total Hours-45

3. <u>Books Recommended:</u>

1 Reliability evaluation of power systems, Roy Billinton, Ronald N. Allan, Springer

2 Reliability evaluation of engineering systems, Roy Billinton, Ronald N. Allan, Springer

3 Distribution reliability, and power quality, t. A. Short, taylor & francis group

4. Reliable and sustainable Electric Power and Energy Systems Management, Roy Billinton, Ajit Kumar Verma, Rajesh Karki, Springer

M. Tech. Power System, Ist year, Semester II	L	T	P	Credit
ENERGY STORAGE AND MANAGEMENT	**3**	**0**	**0**	**03**

EEPS180

1. **Course Outcomes (COs):**

At the end of the course, the students will be able to:

CO1	Describe and compare different energy storage technology and their performance.
CO2	Model various electrochemical storage devices and develop suitable battery management system.
CO3	Identify electrical and magnetic storage systems and their applications.
CO4	Explain and illustrate hydrogen and fuel cells.
CO5	Classify and analyse thermal and mechanical storage systems.
CO6	Design operational strategies for off-grid and on-grid energy storage applications.

2. **Syllabus**

- **Introduction to Energy Storage** **03 hrs.**
  Relevance and scenario, perspective on development of energy storage systems, energy storage criteria, general concepts, fundamentals and applications, energy storage technologies, Ragone plots, future prospect
- **Electrochemical Energy Storage** **06 hrs.**
  Battery technologies and different battery chemistry, electrode materials, electrolytes, performance comparison, reaction mechanism, practical parameters, technical characteristics, equivalent circuit, testing, standards and system sizing, battery storage integration.
- **Battery Management System (BMS)** **10 hrs.**
  BMS functionality, requirements; State Estimation: definitions and their estimation methods; SOH estimation: predictive SOH models prediction models and remaining useful life estimation; Cell balancing: causes of imbalancing, balancing strategies, charge transfer balancing-design choices, circuits for balancing; thermal management of battery; case study.
- **Electrical and Magnetic Storage Systems** **09 hrs.**
  Devices, electrode materials, electrolytes, reaction mechanism, practical parameters, equivalent circuit, testing, standards and system sizing, balancing circuit, applications and challenges; Magnetic Systems- energy storage in superconducting magnetic systems, superconductive materials, applications.
- **Fuel Cells and Hydrogen storage.** **04 hrs**.
  Supercapacitors: Fuel cell: working, basic components, principle, thermodynamics of fuel cell, types, challenges**;** Hydrogen storage-hydrogen as an energy vector and basic principles, hydrogen production, strategies for storing energy in hydrogen, applications.
- **Thermal and Mechanical Storage.** **08 hrs.**
  Basic principle, criteria for TES evaluation, operating characteristics, standards, phase change materials, sensible TES, design and thermal stratification, energy and exergy analyses; Mechanical storage: flywheel, pumped hydropower storage and compressed-air energy storage, comparison and application, principle of operation, function and deployments; case study.
- **Energy Storage Integration and Its Application** **04 hrs.**
  Energy policy and markets, energy storage planning and operation, application and challenges, case study.

Total Hours-45

3. **Books Recommended:**

1 Robert A. Huggins, “Energy storage”, Springer Nature, 2nd edition, 2016.
2 Christopher D. Rahn, and Chao-Yang Wang, “Battery systems engineering”, John Wiley & Sons, 2013.
3 Ibrahim Dincer, and Marc A. Rosen, “Thermal energy storage: systems and applications” John Wiley & Sons, 3rd edition, 2021.
4. Gregory L. Plett, “Battery management systems, Volume II: Equivalent-circuit methods”, Artech House, 2015.
5. Phil Weicker, “A systems approach to lithium-ion battery management”, Artech house, 2013.
6. F. Barnes and J. Levine. "Large energy storage systems", CRC press, 2011.

7. Trevor M. Letcher, Richard Law, and David Reay, “Storing energy: with special reference to renewable energy sources” Vol. 86. Amsterdam: Elsevier, 2016.

Hands-on training: Finite Element Methods in High Voltage Engineering

M. Tech. (Electrical) (Power Systems) (METMV02)	Scheme	L	T	P	Credit
Hands-on training: Finite Element Methods in High Voltage Engineering		0	0	10	5

Course outcomes:

At the end of this course the students will be able to

CO1	Explain Finite Element Method (FEM)
CO2	Develop model using FEM
CO3	Compute electrostatic and electromagnetic field in various model using FEM
CO4	Control electrostatic and electromagnetic field in various model of FEM
CO5	Design and analysis inductor, transformer, rotating electrical machines using FEM

Sl. No.	Theory Topics	Hours
1.	**Introduction** Review of Electromagnetic Field Theory. Review of High Voltage Engineering. Review of Electrical Machine Design	4
2.	**Electrostatic Field Computation** Estimation and Control of Electric Stress	4
3.	**Numerical Methods for Electric Field Computation** Finite Element Method, Charge Simulation Method, Boundary Element Method	6
4.	**Electromagnetic Field Computation** Inductor, Transformer and Rotating Electrical Machine	6

List of the FEM based experiments:

Sl. No.	Name of the FEM based Experiments	Hours
8.	Introduction to Commercial FEM software	10
9.	Modelling and Electrostatic field computation in various electrode systems	10
10.	Modelling and Electrostatic field computation in single phase and three phase Cable, Capacitor, Overhead Transmission Line	20
11.	Modelling and Electromagnetic field computation in air core inductor	10
12.	Modelling and Electromagnetic field computation in Inductor, Transformer, Rotating Electrical Machines	20
13.	Design of Inductor	10
14.	Estimation and Control of electrostatic and electromagnetic stresses in Inductor	10

15.	Design of Transformer	10
16.	Estimation and Control of electrostatic and electromagnetic stresses in Transformer	10
17.	Design of Rotating Electrical Machines	20
18.	Estimation and Control of electrostatic and electromagnetic stresses in Rotating Electrical Machines	20
19.	Continuous Evaluation	30
	Total (Notional Hours)	200

ANNEXURE- III

Post Graduate Programme

M. Tech.

in

Control and Automation

Proposed Curriculum

(as per NEP)

सरदार वल्लभभाई राष्ट्रीय प्रोद्योगिकी संस्थान, सूरत

SARDAR VALLBHBHAI NATIONAL INSTITUTE OF TECHNOLOGY, SURAT

विधुत इंजीनियरिंग विभाग

DEPARTMENT OF ELECTRICAL ENGINEERING

SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY, SURAT
DEPARTMENT OF ELECTRICAL ENGINEERING
Teaching Scheme: M.Tech. in Control and Automation

SEMESTER I

Sr. No.	Course Code	Course	L	T	P	Credits	Examination Scheme				*Notional hours of Learning (Approx.)
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Practical Marks	Total Marks	
1	ELCA101	**Linear System Theory**	3	1	0	04	100	25	-	125	70
2	ELCA103	**Robust and Optimal Control**	3	1	2	05	100	25	50	175	100
3	ELCA105	**Industrial Automation**	3	1	2	05	100	25	50	175	100
4	ELCA1xx	**Elective 1**	3	0	0	03	100	-	-	100	55
5	ELCA1xx	**Elective 2**	3	0	0	03	100	-	-	100	55
		TOTAL	**15**	**3**	**4**	**20**	**500**	**75**	**100**	**675**	**380**
	TOTAL		**22**			**20**					
6	**ELCAV91 ELCAP93**	**Vocational Training/Professional Experience (optional) (Mandatory for exit)**	**0**	**0**	**10**	**05**					

* In accordance with the credit strength of the course and notional hour (s) corresponding to each credit.

SEMESTER II

Sr. No.	Course Code	Course	L	T	P	Credits	Examination Scheme				*Notional hours of Learning (Approx.)
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Practical Marks	Total Marks	
1	ELCA102	**Nonlinear Systems &Control**	3	1	0	04	100	25	-	125	70

2	ELCA104	**Advanced Automation**	3	1	2	05	100	25	50	175	100
3	ELCA1xx	**Elective 3**	3	0	0	03	100	-	-	100	55
4	ELCA1xx	**Elective 4**	3	0	0	03	100	-	-	100	55
5	ELCA1xx	**Institute Elective**	3	0	0	03	100	-	-	100	55
6	ELCA108	**Miniproject**	0	0	04	02	-	-	100	100	70
		TOTAL	**15**	**2**	2	**20**	**500**	**50**	**150**	**700**	**405**
	TOTAL		**19**			**20**					
6	**ELCAV92** **ELCAP94**	**Vocational Training/Professional Experience (optional) (Mandatory for exit)**	**0**	**0**	**10**	**05**					

* In accordance with the 'credit strength of the course' and notional hour (s) corresponding to each credit.

SEMESTER III

Sr. No.	Course Code	Course	L	T	P	Credits	Examination scheme					*Notional hours of Learning (Approx.)
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks	
1	ELCA295	**Dissertation Preliminaries**	-	-	28	14	-	-	140	210	350	
2	-	**MOOC 1 (SWAYAM-NPTEL)**	-	-	-	3/4	-	-	-	-	-	

3	-	**MOOC 2 (SWAYAM-NPTEL)**	-	-	-	3/4	-	-	-	-	-	
		TOTAL	**-**	**-**	**28**	**20-22**	**-**	**-**				
	TOTAL					**20-22**						

* In accordance with the 'credit strength of the course' and notional hour (s) corresponding to each credit.

SEMESTER IV

Sr. No.	Course Code	Course	L	T	P	Credits	Examination scheme					*Notional hours of Learning (Approx.)
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks	
1	ELCA296	**Dissertation**	-	-	40	20	-	-	240	360	600	
		TOTAL	**-**	**-**	**40**	**20**	**-**	**-**	**240**	**360**	**600**	

* In accordance with the 'credit strength of the course' and notional hour (s) corresponding to each credit.

Total: 80-82 credit range

Elective I	
ELCA111	Digital Signal Processing
ELCA113	Embedded Control
ELCA115	Autonomous Vehicles
ELCA117	AI and ML
ELCA119	Mathematical methods in Control

Elective II	
ELCA121	An Introduction to Power Electronic Converters
ELCA123	Control of Renewal Energy Systems
ELCA125	Cyber Physical Systems
ELCA127	Wide Area Power System Control
ELCA129	Process Dynamics and Control

Elective III	
ELCA112	Estimation of Signals and Systems
ELCA114	Internet of Things
ELCA116	Electric Vehicles
ELCA118	Networked Control Systems
ELCA120	Advanced Communications

Elective IV	
ELCA122	Guidance and Fight control
ELCA124	Image Processing
ELCA126	Robotics and Automation
ELCA128	Advanced Control &Instrumentation

Institute Elective	
ELCA172	Automotive Control Systems
ELCA174/EEPE174	Modern Industrial Drives and Automation
ELCA176	Optimization in Control and Automation
ELCA178	Smart Grids
ELCA180	Instrumentation-based System Design
ELCA182	System Identification and Adaptive Control

MOOC Courses I and II	
-	SWAYAM-NPTEL: Specialization and related fields
-	SWAYAM-NPTEL: Specialization and related fields

Note: Throughout this scheme structure, the notations L, T, P, C denote lecture, tutorial, practical and credit respectively for the related subject.

M. Tech. (Electrical)(C&A), Ist year, Semester I

L	T	P	Credit
3	1	0	04

LINEAR SYSTEM THEORY

ELCA101

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Understand the concepts of vector spaces and subspaces
CO2	Explain the concepts of Linear algebra and its application to control theory
CO3	Analyze discrete time systems with Z-transforms
CO4	Evaluate the stability of discrete time systems and obtain the state space representation of discrete time systems
CO5	Design controllers and observers for discrete time systems

2. Syllabus

- **LINEAR ALGEBRA**
  Vector spaces, basis, operator, range of the linear operator, null space, rank, nullity, rank-nullity theorem, matrix representation of the linear operator in the bases, orthogonal bases, Inner product spaces, Holder inequality, Cauchy-Schwartz inequality, triangular inequality, Minkowski inequality, best approximation theorem , orthogonal projection lemma, Gram-Schmidt orthogonalization, Characteristics polynomial, minimal polynomial, eigen value and eigen vector, Diagonal form, Triangular form, Caley- Hamilton Theorem.
- **DYNAMICAL SYSTEM THEORY**
  Axiomatic definition of a dynamical system, Lagrange equation of motion, state plane analysis, numerical technique, Solving Discrete LTI system using Z transformation, pulse transfer function, phase space analysis of the discrete LTI system, Jury Stability criterion, Schur-Cohn test, bilinear transformation applied with Routh's stability criterion. Conservative system, controllability, observability, observer Design, Diophantine equation, Full order, reduced order, minimum order observer.

3. Books Recommended:

1. Kenneth Hoffmann and Ray Kunze**,** Linear Algebra**,** PHI India limited, 1971.
2. Gilbert Strang, Introduction to Linear Algebra, Wellesley Cambridge, 2003.
3. Stanislaw H. Zak, Systems & Control, Oxford University Press, New York, 2003.
4. Wilson J. Rugh, Nonlinear System Theory, The Johns Hopkins University Press, 2002.
5. Krzysztof Kowalski, Willi-Hans Steeb, Nonlinear dynamical systems and Carleman linearization, World Scientific, 1991.

M. Tech. (Electrical)(C&A), Ist year, Semester I

L	T	P	Credit
3	1	2	05

ROBUST AND OPTIMAL CONTROL

ELCA103

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Formulate optimal control problem
CO2	Solve optimal control problems using calculus of variation approach
CO3	Apply Linear Quadratic Regulator for the state space control
CO4	Formulate robust control problem
CO5	Solve H_2 and H_∞ control problems

2. Syllabus

- **INTRODUCTION TO OPTIMAL CONTROL**
  Introduction, Optimization, Optimal control, Plant model, Performance index, Constraints, Formulating an optimal control problem with examples.
- **CALCULUS OF VARIATIONS**
  Concept of functional, Optimum of a functional, The basic variational problem Fixed end point problem, Free end point problem, Extrema of functionals with constraints, Variation approach to optimal control systems, Hamiltonian approach**.**
- **LINEAR QUADRATIC OPTIMAL CONTROL SYSTEMS**
  Finite time linear quadratic regulator problem formulation, Analytical solution of Matrix Differential Riccati Equation (Similarity transformation approach), Infinite horizon regulator problem, Analytical solution of the Algebraic Riccati equation, Frequency domain interpretation of LQR, LQR with a specified degree of stability, Time optimal control systems, Problem formulation, Solution of the time optimal control system.
- **ROBUST CONTROL**
  Systematic formulation of robust control problem, Uncertainty and robustness, Effect on system stability and performance, Performance limitations, Review of measures of signals and systems, H_2 and H_∞ norm computations, Concepts of sensitivity and complementary sensitivity, Classification of perturbations, Linear fractional transformations, Small gain theorem, Parameterization of stabilizing controllers, Solutions to general H_2 and H_∞ control problems, H_∞ loop shaping, and Variable structure control.

List Of Experiments

1. Design and implementation of pole placement-based PI controller for level control of coupled tank system.
2. Design and implementation of pole placement-based PI controller for controlling position of ball in magnetic levitation system.
3. Designing full state feedback regulator using pole placement method for double integrator system.
4. Designing Linear Quadratic Regulator for regulating pitch angle of a spacecraft.
5. Designing Linear Quadratic Regulator for tracking desired pitch angle of a spacecraft.
6. Designing Finite horizon Linear Quadratic Regulator for regulating roll angle of a missile.
7. Designing optimal controller for an inverted pendulum system.
8. Designing full state feedback controller using Linear Quadratic Gaussian Control for a given system.

3. Books Recommended:

1. Donald E. Kirk, Optimal Control: an introduction, Dover Publications, 2006.
2. DesineniSubbaram Naidu, Optimal Control Systems, CRC Press, 2003.
3. Geir E. Dullerud, Fernando Paganini, A Course in Robust Control Theory, Springer, 2010.
4. K. Zhou, J.C. Doyle and K. Glover, Robust & Optimal Control, Prentice Hall Inc. NY 1998.
5. A. Sinha: Linear Systems: Optimal and Robust Control, CRC Press, 2007.

M. Tech. (Electrical)(C&A), Ist year, Semester I

L	T	P	Credit
3	1	2	05

INDUSTRIAL AUTOMATION

ELCA105

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Understand the need of industrial automations
CO2	Learn the overview of Programmable Logic Controller (PLC) systems
CO3	Explain the various Instructions for PLC programming
CO4	Design the ladder logic using PLC
CO5	Develop the ladder logic for various industrial applications

2. Syllabus

Introduction, overview of Industrial Automation, Need for an industrial automation, overview of various controllers.

- **PROGRAMMABLE LOGIC CONTROLLER (PLC)**
  Definition, overview of PLC systems, scan time, scan cycle, power supply, input-output connections, input-output isolations. PLC installation, troubleshooting and maintenance General PLC programming procedures, programming on-off inputs/ outputs.
- **PLC PROGRAMING INSTRUCTIONS/FUNCTIONS**
  Bit logic, timer, Counter instructions, data move, compare, convert instructions, Arithmetic instructions, Analog value processing using PLC. Design of interlocks, sequential logics using PLC, creating ladder diagrams for process control applications.
- **INTRODUCTION TO DISTRIBUTED CONTROL SYSTEMS (DCS)**
  Definition, Local Control Unit (LCU) architecture, LCU languages, LCU - Process interfacing issues, communication facilities, configuration of DCS, displays, redundancy concept Data loggers, Data Acquisition Systems (DAS), Direct Digital Control (DDC). Introduction to Supervisory Control And Data Acquisition Systems (SCADA).
- **CASE STUDY**
  Development of ladder logic for mixing plant, bottle filling plant etc.

List Of Experiments

1. Application of bit logic instructions
2. To develop ladder logic for operating a motor on Jog mode.
3. To develop ladder logic to operate the machine with left and right start button.
4. To develop ladder logic to operate the motor in direct online mode.
5. To develop ladder logic to Control of 35ft long machine with three different operating stations.
6. To develop ladder logic to operate motor in both forward or reverse direction.
7. Application of timers
8. To develop ladder logic in such a way that, when Motor-I is ON, after 10 seconds, Motor-II should be ON automatically. When Motor-I is OFF, Motor-II is OFF automatically.
9. To develop ladder logic to operate three motors in such a way that, when start push button is pressed, Motor-I should turn on, after 5seconds Motor-II will turn on and then after 5seconds Motor-III will turn on. When stop push button is pressed, all motors should stop together.
10. To develop ladder logic to operate two motors in such that, when first motor is on after 5 seconds, second motor is on. When first motor stops then after 5 seconds, second motor stops.
11. To develop ladder logic to operate wood cutting machine and blower such that, as soon as wood cutting machine starts, blower should also start. When machine stops blower should stop after 50 seconds.
12. To develop ladder logic to operate two hooters alternatively ON and OFF for 5 seconds continuously.
13. Application of counters
14. To develop ladder logic to turn on indicator after counting six bottles.
15. To develop ladder logic using counters with compare instructions.
16. To demonstrate data Conversion instructions i.e. Byte-Integer, Integer-Double Integer, Double Integer-Real, Real-Double Integer and Move data from one location to another.
17. To develop ladder logic to process analog inputs.
18. To develop a ladder logic to process analog input and outputs.
19. To demonstrate and develop the ladder logic for PLC based conveyor system.
20. To demonstrate and develop the ladder logic for PLC based pneumatic system.
21. To demonstration closed loop control of speed, temperature, pressure and flow of Air Blower system with PLC and SCADA.

3. Books Recommended:

1. John W. Webb, Programmable controllers, Merrill publishing company, 1988.
2. Poporic Bhatkar, Distributed computer control for industrial equation, Marcel Dekker pub, 1990.
3. Liptak B. G., Process control handbook, Chilton book company,1995.
4. W. Bolton, Programmable Logic Controllers, Newnes; 4 edition, 2006.
5. Kevin Collins, PLC Programming for Industrial Automation, Exposure Publishing, 2007

ELECTIVE-I

M. Tech. (Electrical)(C&A), Istyear, Semester I

L	T	P	Credit
3	0	0	03

DIGITAL SIGNAL PROCESSING

ELCA111

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1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Discuss various signals, systems and its properties
CO2	Analyze various discrete time signals and linear time invariant systems
CO3	Apply DFT, FFT to any discrete time signals
CO4	Design various FIR and IIR filters for given specifications and evaluate using MATLAB
CO5	Discuss various applications of DSP in control engineering

2. Syllabus

- **INTRODUCTION TO SIGNALS AND SYSTEMS**
  Signals, systems and signal processing, classification of signal concepts of discrete-time signals, sampling of analog signal and sampling Theorem, anatomy of digital filters.
- **DISCRETE-TIME SIGNALS AND SYSTEMS**
  Classification, analysis of discrete-time signals and systems, implementation of discrete-time systems, correlation of discrete-time signals, z-transform and its application to the analysis of linear time-invariant systems.
- **DISCRETE AND FAST FOURIER TRANSFORMS**
  Frequency domain sampling, proportion of DFT, efficient computation of DFT: FFT algorithms, Quantization effects in the computation of the DFT.
- **DIGITAL FILTERS**
  Structures of FIR and IIR filters, design of FIR filters using windows, optimum approximations of FIR filters using Parks-McClellan algorithm, Design of IIR filters from analog filters by bilinear transformations; impulse invariance method.
- **APPLICATIONS OF DSP**
  Applications of DSP to Instrumentation and control engineering

3. Books Recommended:

1. Sanjit K. Mitra, Digital Signal Processing: a computer-based approach, McGraw-Hill, 2010.
2. A. V. Oppenheim, R W Schafer, J. R. Buck, Discrete-Time Signal Processing, Prentice Hall, 1998.
3. John G Proakis, Dimitris G. Manolikis, Digital Signal Processing, Principles, Algorithms and Applications, Prentice Hall, 1996.
4. Emmanuel C. Ifeachor, Barrie W. Jervis, Digital Signal Processing A Practical Approach, Pearson Education, 2002.
5. Shlomo Engelberg, Digital Signal Processing An Experimental Approach, Springer, 2008.

M. Tech. (Electrical)(C&A), Ist year, Semester I

L	T	P	Credit
3	0	0	03

EMBEDDED CONTROL

ELCA113

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Understand the fundamentals of different architectures of micro controllers
CO2	Design programs for the 32-bit processor using embedded C language
CO3	Understand the architecture of ARM cortex M
CO4	Implement algorithms on processors for instrumentation and control applications
CO5	Implement algorithms on processors for power electronics and drives

2. Syllabus

- **INTRODUCTION TO ARM CORTEX M ARCHITECTURE**
  RISC and CISC architecture, Harvard and Von Neumann architecture, Cortex M architecture, assembly instructions set, Core buses, on chip peripherals, Memory systems and registers, interrupt processing, bit banding.
- **EMBEDDED C PROGRAMMING**
  Embedded 'C' programming for 32-bit controllers, Introduction to IDE, Registers and variables, Pointers, structures and union, pointer to structure enumeration, conditional compilation directives, pointers to functions, addressing scheme for memory mapped registers, bit filled structure addressing, Interrupt functions in 'C'.
- **INTRODUCTION TO STM 32 (MCU) ARCHITECTURE**
  ARM Cortex M core, bus matrix, AHB and APB buses, different clock domains on MCU, Architecture and Programming of peripherals like GPIO, Timers, PWM Timers, UART, DAC/ADC, SPI, I2C Ports, Hardware debugging techniques.
- **APPLICATIONS**
  Application of 32-bit controllers in instrumentation, control and power electronics and drives.

List Of Experiments

1. Arithmetic operations of Signed and Unsigned Numbers
2. Memory Block Movements (Forward, reverse, overlapping)
3. Ascending and descending arrangement of data string.
4. Code conversion. (Hexadecimal, BCD, Binary, ASCII etc.)
5. Toggling of port pin with time delay
6. Sensing of push button keys
7. Generating different duty cycle and different switching frequency waveform with timer T0 and T2.
8. Generating PWM signal using timer T2 and PCA timer.
9. Generating sine wave and triangular wave using DAC
10. Measuring voltage and current using ADC

3. Books Recommended:

1. Trevor Martin, The Insider's Guide to The STM 32, Published by Hitex (UK) Ltd., April 2005.
2. Joseph Yiu, The Definite Guide to Cortex –M3/M4, Elsevier publication, 2007.
3. Datasheet and user manual of STM F4 series MCU, www.st.com, 2015.
4. Mark Fisher, ARM® Cortex® M4 Cookbook, Packt Publishing, 2016.
5. Yifeng Zhu, Embedded Systems with Arm Cortex-M3 Microcontrollers in Assembly Language and C, E-Man Press LLC, 2014.

M. Tech. (Electrical)(C&A), Ist year, Semester I

L	T	P	Credit
3	0	0	03

AUTONOMOUS VEHICLES

ELCA 115

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Understand the rational for and evolution of automotive electronics
CO2	Understand the fundamental theory of operation of electronic control systems
CO3	Understand the concept of remote sensing and the types of sensor technology required
CO4	Understand the basic concepts of wireless communications and wireless data networks
CO5	Understand the principles of ADAS and future autonomous vehicles

2. Syllabus

- **Introduction to Automated Vehicles**
  Introduction to Automated, Connected, and Intelligent Vehicles, Introduction to the Concept of Automotive Electronics, Automotive Electronics Overview, History & Evolution, Infotainment, Body, Chassis, and Powertrain Electronics, Advanced Driver Assistance Electronic Systems, Connected and Autonomous Vehicle Technology, Basic Control System Theory applied to Automobiles, Overview of the Operation of ECUs, Basic Cyber-Physical System Theory and Autonomous Vehicles, Role of Surroundings Sensing Systems and Autonomy, Role of Wireless Data Networks and Autonomy.
- **Sensor Technology for Driver Assistance**
  Sensor Technology for Advanced Driver Assistance Systems, Basics of Radar Technology and Systems, Ultrasonic Sonar Systems, Lidar Sensor Technology and Systems, Camera Technology, Night Vision Technology, Other Sensors, Use of Sensor Data Fusion, Integration of Sensor Data to On-Board Control Systems.
- **Connected Car and Driver Assistance Technology**
  Connectivity Fundamentals, Navigation and other applications, vehicle-to-vehicle technology and applications, vehicle-to-roadside and infrastructure applications, Basic theory of driver assistance, integration of ADAS technology into vehicle electronics, role of sensor data fusion
- **Wireless Networking and Applications to Vehicle Autonomy**
  Basics of computer networking- the internet of things, wireless networking fundamentals, integration of wireless networking and on-boardvehicle networks, connected car display technology, Examples of present advanced driver assistance system technology.

3.Books Recommended:

1. D. Paret, H. Rebaine, B. A. Engel, Autonomous and Connected Vehicles: Network Architectures from Legacy Networks to Automotive Ethernet, 1st Edition, Wiley, 2022

2. G. Mullet, Wireless Telecommunications Systems and Networks, Thomson-Delmar Learning, 2006

M. Tech. (Electrical)(C&A), Ist year, Semester I

L	T	P	Credit
3	0	0	03

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

ELCA117

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Identify potential areas for automation
CO2	Explain "Artificial" Intelligence and how to identify systems with Artificial Intelligence.
CO3	Impart knowledge about the concepts of machine learning
CO4	Implement Machine Learning method for the problems of dynamics

2. Syllabus

- **INTRODUCTION TO ARTIFICIAL INTELLIGENCE**
  Introduction: Overview and Historical Perspective, Turing test, Physical Symbol Systems and the scope of Symbolic AI, Agents. State Space Search: Depth First Search, Breadth First Search, DFID. Heuristic Search: Best First Search, Hill Climbing, Beam Search, Tabu Search. Randomized Search: Simulated Annealing, Genetic Algorithms, Ant Colony Optimization. Finding Optimal Paths: Branch and Bound, A*, IDA*, Divide and Conquer approaches, Beam Stack Search.
  Problem Decomposition: Goal Trees, AO*, Rule Based Systems, Rete Net. Game Playing: Minimax Algorithm, AlphaBeta Algorithm, SSS*. Planning and Constraint Satisfaction: Domains, Forward and Backward Search, Logic and Inferences: Propositional Logic, First Order Logic, Soundness and Completeness, Forward and Backward chaining.
- **MACHINE LEARNING CONCEPTS**
  Machine learning basics: capacity, over fitting and under fitting, hyper parameters and validation sets, bias & variance; PAC model; Rademacher complexity; growth function; VC-dimension; fundamental concepts of artificial neural networks; mathematical preliminaries and data visualization, supervised and unsupervised learning, logistic regression, Neural networks: CNN, RNN, LSTM, deep networks.
  Machine Learning methods and techniques in computational dynamical systems and control. Data-driven models, models from first principles, their computational complexity and Machine Learning methods.

3. Books Recommended:

1. Deepak Khemani, *A First Course in Artificial Intelligence,* McGraw Hill Education (India), 2013.
2. Stuart Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach,* 3rd ed., Prentice Hall, 2009.

3. Mohri, M., Rostamizadedh, A., and Talwalkar, A., *Foundations of Machine Learning*, The MIT Press (2012).
4. Jordon, M. I. and Mitchell, T. M., *Machine Learning: Trends, perspectives, and prospects*, Vol. 349, Issue 6245, pp. 255-260, Science 2015.
5. John D. Kelleher, Brian M. Namee and Aoife D'Arcy, *Fundamentals of Machine Learning for Predictive Data Analytics*: Algorithms, Worked Examples, and Case Studies, The MIT Press, 2015.

M. Tech. (Electrical)(C&A), Ist year, Semester I

L	T	P	Credit
3	0	0	03

MATHEMATICAL METHODS IN CONTROL

ELCA119

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Understand the fundamentals of vector space and bases in reference to transformations
CO2	Solve system of linear equations using direct and iterative methods
CO3	Use the idea of eigen values and eigen vectors for the application of SVD
CO4	Describe the basic notions of discrete and continuous probability distributions
CO5	Find out responses of linear systems using statistical and probability tools

2. Syllabus

- **ALGEBRAIC METHODS in Control**
  , Linear transformations, Matrix form of linear transformations, Norms, Matrix Factorization, Solution of linear equations, Eigen values and eigen vectors, Complex vectors and Matrices, Jacobi method & Givens method for symmetric matrices, Orthogonal vectors and orthogonal bases, Gram-Schmidt orthogonalization process, SVD and Applications, Controllability Space, Sum of the Vector Space, Direct Sum, Orthogonal Projection Lemma, Jordan Forms of matrices, Diffeomorphism
- **PROBABILITY THEORY**
  Probability: Random variables, Probability distributions: Binomial, Poisson, Normal distributions, Joint probability distribution (discrete and continuous), Functions of random variables and random vectors, Moments, Central moments, Characteristic functions and correlation matrices, Probability generating and moment generating functions, Gaussian, Weibull and Erlang distributions with examples.

3. Books Recommended:

1. David C.Lay, Steven R.Lay and J.J.McDonald: Linear Algebra and its Applications, 5 th Edition, Pearson Education Ltd., 2015.
2. Gilbert Strang, Introduction to Linear Algebra, 5 th Edition, Wellesley-Cambridge Press, 2016.
3. A. Papoulis & S U Pillai, Probability, Random Variables and Stochastic Process, 4 th Edition, Mc Graw Hill, 2002.
4. H. Stark & J.W. Woods, Probability and Random processes with Applications to Signal Processing, Pearson Education Asia, 2002.
5. J A Gubner: Probability and Random processes for Electrical and Computer engineers, Cambridge Univ. Press. 2006.

ELECTIVE-II

M. Tech. (Electrical)(C&A), Istyear, Semester I

AN INTRODUCTION TO POWER ELECTRONICCONVERTERS

L	T	P	Credit
3	0	0	03

ELCA121

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Explain the basic principle of power devices and circuit
CO2	Derive the equations and applications for dc/dc converters
CO3	Derive the equations and applications for inverters
CO4	Application and performance analysis of Power Electronic circuits
CO5	Analyze the performance of control algorithm in Power Electronic circuits

2. Syllabus

- **BASICS OF POWER SEMICONDUCTOR DEVICES AND CIRCUITS**
  Characteristics and specification of power devices- Thyristor, IGBT, MOSFET, GTO, diodes and new developments, development of control circuits, Application of freewheeling diodes, response of inductor and capacitor, Power and power factor, Single and three phase control and uncontrolled rectifiers, semi converters, AC voltage controllers- control and applications.
- **DC-DC CONVERTERS**
  Buck converter, Boost converter, Buck- Boost converters, CUK converter, Fly-back converter, Forward converter, Push-pull converter, Full bridge and Half bridge converters, Single input and multi output converters, Open loop and closed loop control, switching scheme, Design considerations and comparison, Application in selected area- transportation and lighting system etc.
- **INVERTERS**
  Review of single-phase bridge inverters, 3-phase bridge inverters, Pulse width modulated inverters, 1-pulse Selective and multi pulse modulation, Sinusoidal PWM, Space Vector PWM, other PWM techniques, Reduction of harmonics Harmonic Elimination Technique, interface of power circuit and control circuit, UPS: types, Design and control.
- **APPLICATION OF POWER ELECTRONICS**
- Active filters- Design and control, standards, Power quality, Application of power electronics in renewable energy system- Solar, Wind and Hydro and others, various type of generators, Parameter estimation and control for ac drives- induction motor and synchronous motors.
- **CONTROL ALGORITHM FOR POWER ELECTRONIC CIRCUITS**

Adaptive control algorithms for power electronics circuit-Least means square methods, Design of observers, PI and PID controller- conventional and auto gain tunning, Frequency domain control, Application of soft computing methods.

3. Books Recommended:

1. Rashid, M. H., Power Electronics Circuits, Devices, and Applications, third edition, Pearson education, New Delhi, , 2009.
2. Ned Mohan, Tore M. Undeland and William P. Robbins,Power Electronics Converters, Applications, and Design, John Willey & Sons, Inc., 2nd Edition, 1995.
3. Rashid, M. H., Power Electronics: Hand book, Academic Press, California, 2001.
4. Simon Haykin, Adaptive filter Theory, Pearson education Inc., Delhi, 2002.
5. Jang, T. Sun and E. Mizutani, Neuro-Fuzzy and Soft computing: a computational approach to learning and machine intelligence, Pearson Education Inc, Delhi, 1997.
6. S.N. Sivanandam and S.N. Deepa, Principles of soft computing, 2ed edition, Wiley India, New Delhi, 2011.

M. Tech. (Electrical) (C & A), Ist year, Semester I

L	T	P	Credit
3	0	0	03

CONTROL OF RENEWABLE ENERGY SYSTEMS

ELCA123

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Understand and explain present energy status and renewable energy needs
CO2	Analyze the photovoltaic fundamentals and the photovoltaic applications
CO3	Analyze the wind turbine characteristics and the wind power system generation
CO4	Understand and select different electrical machines and power converters for wind energy generation
CO5	Explain different hybrid renewable energy generation systems and their power control

2. Syllabus

- **PRESENT STATUS OF FOSSIL FUELS BASED GENERATION AND NEED FOR RENEWABLES**
  Present status of fossil fuel resources in the world and India, limitations of the fossil fuel electricity generation, need for renewable energy and present status in India.
- **SOLAR PHOTOVOLTAICS DEVICES AND CHARACTERISTICS**
  Review of p-n junction diode, exposure to sunlight, PV characteristics and environmental impact, PV devices and modelling, need for maximum power point tracking
- **PHOTOVOLTAICS POWER ELECTRONICS CONVERTERS, THEIR CONTROL AND GRID INTEGRATION**
  PV-MPPT algorithms, basic DC-DC converters (buck, boost, buck-boost) and their controls, single-phase and three-phase grid connected PV inverters and their control, design of standalone PV systems for irrigation pump and domestic applications.
- **PHOTOVOLTAIC-BATTERY ENERGY STORAGE**
  Types of batteries, battery terminology, characteristics and modelling, battery charging methods, integrating battery-charge control with MPPT, design of standalone PV-battery system.
- **WIND TURBINES AND CHARACTERISTICS**
  Wind data in terms of speed-frequency distribution, power density-speed duration curves, different wind turbines and their characteristics, wind power and energy computations, components of wind turbine system.
- **ELECTRICAL MACHINES, POWER ELECTRONICS CONVERTERS AND GRID INTERFACE FOR WIND ENERGY**
  Fixed and variable wind speed turbines, induction and synchronous machines for wind energy conversion, different power electronics interface based on full and partial converters, wind-MPPT algorithms, wind-farm configurations.

- **SOLAR AND WIND HYBRID SYSTEMS**
  Hybrid systems and their needs, solar-diesel-battery systems, wind-solar-battery system, solar-wind-fuel cell system and its control.

3. Books Recommended:

1. Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications, Third Edition, PHI Learning Private Limited, New Delhi, 2015.
2. Weidong Xiao, Photovoltaic Power Systems: Modelling, design and control, First Edition, John Wiley & Sons Limited, NJ USA, 2017.
3. Thomas Ackermann, Wind Power in Power System, John Willey & Sons, 2005.
4. J. K. Nayak and S. P. Sukhatme, Solar Energy - Principles of Thermal Collection and Storage, Fourth Edition, Tata McGraw Hill, New Delhi, 2017.
5. R. Teodorrescu, Marco Liserre and Pedro Rodriguez, Grid Converters for Photovoltaic and Wind Power Systems, First Edition, John Wiley & Sons Limited, UK, 2011.

M. Tech. (Electrical)(C&A), Ist year, Semester I

L	T	P	Credit
3	0	0	03

Cyber-Physical Systems

ELCA125

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Understand the core principles behind CPS
CO2	Identify safety specifications and critical properties
CO3	Understand the abstraction in system design
CO4	Understand AI based CPS

2. Syllabus

- **Introduction**
  Cyber-physical systems (CPS) introduction, Key features of CPS, the application domain of CPS, Basic principles of design and validation of CPS, Challenges in CPS
- **Dynamical Systems Modeling**
  Cyber-Physical Systems (CPS) in the real world, Dynamical Systems: stability and performance, Different notions of stability, Controller Design techniques, Logic based system specification, Controller Synthesis as a logic problem
- **CPS Compute/Communicate/Scheduling**
  Real-time scheduling theory, CAN bus scheduling, Wireless CPS, Packet drops and their effects on stability/performance, Delay/Deadline-miss aware control design. CPS performance analysis: effect of scheduling, bus latency, sense and actuation faults on control performance.Methods for safety assurance of CPS, Advanced automata-based modeling and analysis, basic introduction and examples, timed and hybrid automata, definition of trajectories, Flow pipe construction, reachability analysis.
- **Safe-AI based and Secure CPS**
  Safe Reinforcement learning for CPS, MPC plus Gaussian Process learning for CPS, Distributed CPS: Cooperative driving, Attack detection, and mitigation in CPS, Smart Grid Security and Privacy: Automated Generation Control attacks and privacy aware metering. State estimation for attack detection. Automotive case study: vehicle ABS hacking, Power distribution case study: Attacks on Smart Grids

3. Books Recommended:

1. E.A. Lee, S.A. Seshia, Introduction to Embedded Systems: A Cyber-Physical Systems approach, 2011
2. R. Alur, Principles of Cyber-Physical Systems, MIT Press, 2015
3. T.D. Lewis, Network Science: Theory and Applications, Wiley, 2009
4. P. Tabuada, Verification and Control of Hybrid Systems: A Symbolic Approach, Springer-Verlag, 2009.

M. Tech. (Electrical)(C&A), Ist year, Semester I

L	T	P	Credit
3	0	0	03

WIDE AREA POWER SYSTEM CONTROL

ELCA127

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Explain various Synchrophasor Measurement Techniques
CO2	Implement and test wide area measurement systems
CO3	Realize optimal placement of PMU and state estimation using PMU data
CO4	Monitor, analyse and control power system conditions in real time
CO5	Interpret wide area PMU measurements

2. Syllabus

- **PHASOR MEASUREMENT TECHNIQUES**
  Phasor Measurement Techniques: Basic Concepts and Definitions SCADA vs PMU, Synchrophasors, Frequency, and ROCOF, Steady-State and Dynamic Conditions in Power Systems, Classical Phasor Versus Dynamic Phasor, Basic Definitions of Accuracy Indexes, Algorithms for Synchrophasors, Frequency, and ROCOF, Methods to Calculate Synchrophasors based on a Steady-State Model and Dynamic Signal Model, Evaluation of Frequency and ROCOF, Dynamic Behavior of Phasor Measurement Algorithms.
- **PHASOR MEASUREMENT UNITS AND PHASOR DATA CONCENTRATORS**
  Phasor measurement units and Phasor data concentrators: WAMS architecture, Sensors for PMUs, International Standards for Instrument Transformers, Accuracy of Instrument Transformers, Transducer Impact on PMU Accuracy, Hardware for PMU and PMU Integration, PMU Architecture, Data Acquisition System, Synchronization Sources, Communication and Data Collector, Distributed PMU, International Standards for PMU and Tests for Compliance, IEC 61850.
- **STATE ESTIMATION**
  State Estimation and PMUs: Formulation of the SE Problem, Network Observability-SE Measurement Model, SE Classification, State estimation with phasor measurents, Linear state estimation, Dynamic estimators. Optimal PMU placement, meta-heuristic and deterministic algorithms, Integer Linear Programming Technique.
- **WIDE AREA MONITERING SYSTEM**
  WAMS applications- real-time analysis and technologies to detect, locate and characterize power system disturbances, monitoring power system oscillatory dynamics- Interpretation and visualization of wide-area PMU measurements, power system control with phasor feedback, discrete event control.

3. **Books Recommended:**

1. Antonello Monti, Carlo Muscas, Ferdinanda Ponci, Phasor Measurement Units and Wide Area Monitoring Systems, Academic Press, 2016.
2. A.G. Phadke, J.S. Thorp, Synchronized Phasor Measurement and Their Applications, Springer 2008.
3. Yong Li, Dechang Yang, Fang Liu, Yijia Cao, Christian Rehtanz, Interconnected Power Systems: Wide-Area Dynamic Monitoring and Control Applications, Springer, 2015.
4. Ali Abur, Antonio Gómez Expósito, Power System State Estimation: Theory and Implementation, CRC Press, 2004.
5. Ma J., Makarov Y., Dong Z, Phasor Measurement Unit and its Applications on Modern Power Systems, Springer, 2010.

M. Tech. (Electrical)(C&A), Ist year, Semester I

L	T	P	Credit
3	0	0	3

PROCESS DYNAMICS AND CONTROL

ELCA129

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Understand the principles of mathematical modelling such that transfer function and state-space models can be developed
CO2	Understand the dynamic behaviour of simple as well as complex processes
CO3	Design, implement and tune controllers for different complex as well as unstable systems
CO4	Design, implement and evaluate the performance of controllers for benchmark process control problems
CO5	Identify, formulate and solve problems in the process control domain

2. Syllabus

INTRODUCTION TO PROCESS MODELING
Terms, motivation and objectives. Piping and instrumentation diagram, instrument terms and symbols. Definition of process variables. General modelling principles: steady state and unsteady state. Dynamic models of representative processes: thermal and liquid storage system. Development of transfer function and state-space models, interacting and non-interacting processes. Linearization of nonlinear models, degrees of freedom analysis.

DYNAMIC BEHAVIOUR OF PROCESSES
Standard process inputs and their significance, dynamic behaviour of first and second order processes. Processes with numerator dynamics and their response to standard inputs: first and second order. Process with time delay, Pade’s approximations, Skogestad’s “Half Rule”. Approximation of higher order systems to first and second order with time delay.

FEEDBACK CONTROLLERS
Basic control modes: On-Off control, proportional, integral and derivative control, features and limitations. Proportional-integral-derivative control, features, elimination of derivative and proportional kick, reset windup. Typical responses of feedback controllers.

- **DESIGN OF FEEDBACK CONTROLLERS**
Model based design methods: direct synthesis method, internal model control. Online controller tuning: continuous cycling method, step test method. Design of controllers for simple and complex processes. Elimination of offset, control of unstable systems, integrating processes. Evaluation criteria: IAE, ISE, ITAE. Implementation of control algorithms to benchmark process control problems: coupled-tanks/quadruple tank system.

3. Books Recommended:

1. Dale E. Seborg, Thomas F. Edgar, Duncan A. Mellichamp, Francis J. Doyle III, Process Dynamics and Control, 3rd Edition, John Wiley & Sons, Inc., 2011.

2. B. Wayne Bequette, Process Control: Modeling, Design, and Simulation, Prentice Hall, Prentice Hall, 2003.
3. Curtis D. Johnson, Process Control Instrumentation Technology, 8th Edition, Pearson Education India, 2015.
4. George Stephanopoulos, Chemical Process Control: An Introduction to Theory and Practice, Pearson Education India, 2015.
5. Bela G. Liptak, Process Control, 3rd Edition, Butterworth-Heinemann, 2013.

M. Tech. (Electrical)(C&A), Ist year, Semester

INTRODUCTORYINDUSTRIAL AUTOMATION TRAINING/INTRODUCTORYINDUSTRIAL AUTOMATION Professional experience

ELCAV91/ELCAP93 (5 credits, 10 hours)

Industrial controllers: PLC basics and architectures, PLC - IEC 61131-3 programming languages & visualization, architecture of PLC different modules, power supply unit, etc.

Different types of sensors: sinking, sourcing, NPN, PNP connections with PLC, monitoring the process through sensors: connection details, structured programming (function & function blocks), analog addressing, continuous process monitoring and control, configuring alarms.

Different types of controllers: on/off, proportional, derivative, integral and PID control, PLC programming of branded PLCS, concepts, data file handling: forcing I/O, wiring and fault corrections, programming practices, case studies.

M. Tech. (Electrical)(C&A), 1st year, 2nd Semester

ADVANCEDINDUSTRIAL AUTOMATION TRAINING/ADVANCED INDUSTRIAL AUTOMATION PROFESSIONAL EXPERIENCE

ELCAV92/ELCAP94 (5 credits, 10 hours)

Supervisory control and data acquisition / human machine interface, introduction to SCADA, role of SCADA in industrial automation.

SCADA:network communications & communication with RTUs, analog/digital, communications on plant floors, communication standards / OPC server (OLE for process control)/PLC (RTU), and SCADA Interface configuration concepts.

SCADA system configuration, RTU, communication protocols, script programming, real time and historical trends, configuring alarms, real time project development with PLC interfacing, communication with other softwares.

SEMESTER II

M. Tech. (Electrical)(C&A), Ist year, Semester II
Nonlinear Systems and Control

L	T	P	Credit
3	1	0	04

ELCA102

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Analyse nonlinear systems using classical techniques
CO2	Analyse stability of non linear systems using advanced techniques
CO3	Analyse nonlinear feedback systems using time and frequency domain techniques
CO4	Design controllers for nonlinear systems using advanced methods

2. Syllabus

- **Introduction and classical techniques**
  Characteristics of nonlinear systems, examples of systems exhibiting nonlinear phenomena,secondorder nonlinear autonomous systems, vector field representation, classification of equilibrium points, qualitative behavior near equilibrium points, limit cycles, existence of periodic orbits, Poincare-Bendixon criterion, Poincare index of equilibrium points,stability of periodic solutions, analysis ofsystems with piecewise constant inputs using phase plane analysis, Jump response.
- **Lyapunov stability**
  Existence and uniqueness of solutions of nonlinear state equations,stability of nonlinear systems, Lyapunov stability, local linearization and stability in the small Centre manifold theorem, Direct method of Lyapunov, generation of Lyapunov function for linear and nonlinear systems,Variablegradient method, La Salle's Invariance theorem, Input to state stability, L stability, L stability of state models, Small gain theorem, Passivity, Positive real transfer functions, L2 and Lyapunov stability, Passivity theorems, Loop transformation
- **Time domain analysis of feedback systems and perturbation techniques**
  Absolute stability of feedback interconnections of a linear part and nonlinear part, Circle criterion, Popov criterion, Frequency theorem, Harmonic linearization, filter hypothesis,Describing function of standard nonlinearities, amplitude and frequency of limit cycle using SIDF, Pertubation techniques, Regular perturbation, Singular perturbation.
- **Nonlinear system design**
  Control problems, stabilization via linearization, integral control via linearization, Gain scheduling, Feedback linearization, stabilization and tracking via state feedback control, Sliding mode control, Regulation via integral control, Control-Lupunov and Lyapunov design, Lasalle invariance principle, Lyapunov redesign, stabilization and nonlinear damping, Backstepping, Passivity based control, High gain observers. Linear Quadratic Regulators/Linear Quadratic Guassian Regulators, Numerical Solution for Riccatti Equations.

3. **Books Recommended:**

1. H. K. Khalil, ‘Nonlinear Systems’, Prentice - Hall International (UK), 1996
2. J.J.E. Slotine& W.LI, ‘Applied Nonlinear Control’, Prentice Hall, EngelwoodNewJersey, 1991
3. H. Nijmeijer& A.J. Van Der schaft, ‘Nonlinear Dynamic control Systems’, Springer Verlag Berlin, 1990
4. Z. Vukic &L.Kuljaca, ‘Nonlinear Control Systems’, Marcel Dekker, Inc., New York, 2003
5. Eduardo D. Sontag, Mathematical Control Theory, Second Edition, Springer, 1991.

M. Tech. (Electrical)(C&A), Ist year, Semester II

L	T	P	Credit
3	1	2	05

ADVANCED AUTOMATION

ELCA104

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Explain the advanced controller for Industrial automation
CO2	Develop the ladder logic with high end PLC instructions
CO3	Discuss industrial communication
CO4	Develop and configure SCADA and HMI with PLC
CO5	Design the ladder logic for various industrial applications with PLC and SCADA

2. Syllabus

- **ADVANCED CONTROLLERS FOR INDUSTRIAL AUTOMATION**
  Introduction, definition, High end PLC programming Instructions, arithmetic functions, comparison functions, analog input and output, subroutine instructions, interrupt instruction. PID Tuning, close loop speed control, closed loop temperature control. Design of ladder diagrams for various applications.
- **INDUSTRIAL COMMUNICATION**
  Industrial Instrumentation Communication and Networking– RS232, RS485, Modbus, HART, Fieldbus, Profibus, Serial Communications, etc.
- **SCADA AND HMI**
  Basics of SCADA, creating new SCADA applications, tag generation, screen development, Buttons, numeric display and input, animated object, trends, report, alarm, SCADA communication and protocols etc. Communication of SCADA with PLC.
  HMI Basics and types of HMI, creating new HMI program, tag generation, screen development, buttons, numeric display and input, alarm, HMI communication and protocols, etc.
  IoT based control systems.

- **CASE STUDY**
  Industrial automation in various industries, like chemical, textile, oil and Gas, food and beverages etc.

List Of Experiments

Experiments will be performed based on the case studies related to industrial processes and drives applications using PLC, VFD and HMI/SCADA.

3. Books Recommended:

1. John Webb, Programmable Logic Controllers Principles & Applications, Prentice Hall of India, 1st Edition, 2013.
2. Andrews, Applied Instrumentation in Process Industries, Gulf Professional Publishing; 2nd Edition, 1979.
3. D. Patranabis, Principles of Process Control, Tata Mcgraw Hill, 3rd Edition, 2017.
4. S. K. Singh, Computer Aided Process Control, Prentice Hall of India, 2004.
5. Kevin Collins, PLC Programming for Industrial Automation, Exposure Publishing, 2006.

ELECTIVE-III

M. Tech. (Electrical)(C&A), Ist year, Semester II

ESTIMATION OF SIGNALS AND SYSTEMS

ELCA112

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Make use of the concepts of random processes for formulating problems in stochastic estimation framework
CO2	Implement Kalman filter to solve linear estimation problems, and to analyze the estimation accuracy
CO3	Implement nonlinear Kalman filters for solving nonlinear estimation problems, and to analyze the estimation accuracy
CO4	Develop estimators for different types of linear and nonlinear systems
CO5	Analyse and decide the usefulness of estimators for the trajectory estimation and control of autonomous systems, and process control problems

2. Syllabus

- **ESTIMATION AND PRELIMINARIES**
  Definition for state and parameter estimation, Need of estimation in control, Concepts of random experiments, sample space, probability function, random variable, scalar and vector random variables, cumulative distribution function, probability density function, and their properties. Commonly used random variables, scalar and multivariate Gaussian probability density, properties, moments of random variables: mean, autocorrelation, variance, covariance, cross-correlation, crosscovariance. Marginal and conditional probability density, Bayes' rule, independent and identically distributed random variables.
- **BASICS OF ESTIMATION: LINEAR SYSTEMS**
  Estimation of a constant vector from noisy measurements: weighted least squares (WLS) estimator, minimum variance linear estimator, best linear unbiased estimator (BLUE). Minimum variance linear estimator with prior knowledge, maximum likelihood estimation (MLE), maximum a posteriori estimate (MAP).
  Initial state estimation using a batch of data: WLS and recursive WLS. Recursive linear minimum mean square error (LMMSE), Bayesian framework for estimation, Kalman filter, assumptions and conditions for optimality.
- **NONLINEAR ESTIMATION IN CONTROL**
  Bayesian framework for nonlinear state estimation, extended Kalman filter (EKF), unscented Kalman filter (UKF), implementation of Kalman filters for solving control problems in tracking and navigation problems, process control problems etc. Wiener's theory of optimization, application of Wiener's theory in the compensator design for feedback control systems

3. Books Recommended:

1. A. H. Jazwinski, Stochastic Processes and Filtering Theory, Academic Press, 1970.
2. P. S. Maybeck, Stochastic Models, Estimation and Control: Volume 1, Academic Press,1979.
3. H. J. Kushner, Stochastic Stability and Control, New York: Academic Press, 1967.
4. Y. Bar-Shalom, X. R. Li, T. Kirubarajan, Estimation with Applications to Tracking and Navigation: Theory, Algorithms and Software, John Wiley & Sons, Inc., 2002.
5. D. Simon, Optimal State Estimation: Kalman, H Infinity, and Nonlinear Approaches, John Wiley & Sons, Inc., 2006.

M. Tech. (Electrical)(C&A), Ist year, Semester II

L	T	P	Credit
3	0	0	03

INTERNET OF THINGS

ELCA114

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Discover the application areas of IoT
CO2	Realize the revolution of Internet in Mobile Devices, Cloud & Sensor Networks
CO3	Describe the building blocks of Internet of Things and characteristics
CO4	Explain cloud-based sensor data analysis
CO5	Designing an IoT system

2. Syllabus

- **ELEMENTS OF AN IoT**
  Elements of an IoT ecosystem, Technology drivers, Business drivers, Typical IoT applications, Overview of IoT supported Hardware platforms such as: Raspberry pi, ARM Cortex Processors, Arduino and Intel Galileo boards, IoT architecture: History of IoT, M2M - Machine to Machine, Web of Things, IoT protocols, Internet of Things (IoT) and Web of Things (WoT), Internet and Web Layering Business aspects of the Internet of Things, Representational State Transfer (REST) and Activity Streams, Business Cases & Concepts Persuasive Technologies.
- **NETWORKING EQUIPMENT**
  Overview and working principle of Wired Networking equipment, Router, Switches, Overview and working principle of Wireless Networking equipment, Access Points, Hubs, etc. Linux Network configuration concepts: Networking configurations in Linux Accessing Hardware & Device Files interactions.
- **NETWORK FUNDAMENTALS**
  Network Fundamentals: Anatomy of a Sensor Network, Examples of Sensor Networks, Topology of a Sensor Network Communication Media. Wired Networks, Wireless Networks, Hybrid Networks. Types of Sensor Nodes, How Sensors Measure Storing Sensor Data. XBee Primer, Building an XBee-ZB Mesh Network, Arduino-Based Sensor Nodes, Hosting Sensors with Raspberry Pi.
- **IoT TUTORIAL AND MINI-PROJECT**
  Storing Sensor Data, Storage Methods - Local Storage Options for the Arduino, Local Storage Options for the Raspberry Pi, Remote Storage Options, MySQL Local processing on the sensor nodes, Connecting devices at the edge and to the cloud, Processing data offline and in the cloud, Mini-project: Designing an IoT system.

3. Books Recommended:

1. J. Biron and J. Follett, Foundational Elements of an IoT Solution, O'Reilly Media, 2016.
2. Charles Bell, Beginning Sensor Networks with Arduino and Raspberry Pi ,Apress, 2013.
3. D. Evans, The Internet of Things: How the Next Evolution of the Internet Is Changing Everything, Cisco Internet Business Solutions Group, 2011.
4. McKinsey&Company, The Internet of Things: Mapping the value beyond the hype, McKinseyGlobal Institute, 2015.
5. European Alliance for Innovation (EAI), Internet of Things: Exploring the potential, InnovationAcademy Magazine, Issue No. 03, 2015.

M. Tech. (Electrical)(C&A), Ist year, Semester II

L	T	P	Credit
3	0	0	03

ELECTRIC VEHICLES

ELCA116

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1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals
CO2	Analyze the use of different power electronics converters and electrical machines in electric vehicles
CO3	Able to interpret the working of different configurations of electric vehicles and its components, hybrid vehicle configurations
CO4	Explain the use of different energy storage systems used for electric vehicles, their control techniques, and select appropriate energy balancing technology
CO5	Ability to understand the control and configurations of HEV charging stations

2. Syllabus

- **INTRODUCTION**
  Vehicle Basics, vehicle model, Vehicle Resistance: Rolling Resistance, Aerodynamic Drag, Grading Resistance, Dynamic Equation Tire–Ground Adhesion and Maximum Tractive Effort, Power Train Tractive Effort and Vehicle Speed, EV Powertrain Component Sizing. Hybridization of the Automobile: Basics of the EV, Basics of the HEV, Basics of Plug-In Hybrid Electric Vehicle (PHEV) and vehicle architectures
- **POWER ELECTRONICS IN EV**
  Power electronics circuits used for control and distribution of electric power in DC-DC, AC-DC, DC-AC converters used for EV. Electric Machines and Drives in EVs: Fundamental of Drives and Control of EV Using DC motor, Induction Motor, Permanent Magnet Motor, Switched Reluctance Motor, BLDC motor, Design and Sizing of Traction Motors.
- **ENERGY STORAGE ELEMENTS**
  Batteries, Ultracapacitor, Fuel Cells, and Controls: Introduction, Different batteries for EV, Battery Characterization, Comparison of Different Energy Storage Technologies for HEVs, Battery Charging Control, Charge Management of Storage Devices, Flywheel Energy Storage System, Fuel Cells and Hybrid Fuel Cell Energy Storage System and Battery Management System
- **EV CHARGING TECHNOLOGIES**
  Classification of different charging technology for EV charging station, introduction to Grid-to-Vehicle, Vehicle to Grid (V2G) or Vehicle to Buildings (V2B) or Vehicle to Home (V2H) operations, bi-directional EV charging systems, energy management strategies used in hybrid and electric vehicle, Wireless power transfer (WPT) technique for EV charging.

3.**Books Recommended:**

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003
4. Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd., 2011

M. Tech. (Electrical)(C&A), Ist year, Semester II

NETWORKED CONTROL SYSTEMS

ELCA118

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Integrate the basic concepts to formulate networked control problems
CO2	Describe various decentralized control strategies for networked control systems
CO3	Develop various control strategies for multi-agent robotics
CO4	Develop models and strategies for mobile sensor and communication networks
CO5	Develop decentralized control strategies

2. Syllabus

- **BASIC CONCEPTS IN NETWORKED CONTROL**
  Review of Graph Theory-Connected Graph-Incidence Matrix-Tree-cutset-loop/cycles-Minimum Spanning Tree-Network Models -graphs, random graphs, random geometric graphs, state-dependent graphs-Networked control systems-Proximity graphs - Algebraic and spectral graph theory - Connectivity: Cheeger's inequality -switching networks- From biological swarms to graph-based models-Rendezvous: A canonical problem
- **DECENTRALIZED CONTROL**
  The agreement protocol: static case- Reaching decentralized agreements- Consensus equation: Static case- Leader networks and distributed estimation- Discrete time consensus. The agreement protocol: dynamic case: Switched networks- Lyapunov-based stability- Consensus equation: Dynamic case-Biological models: Flocking and swarming- Alignment and Kuramoto's coupled oscillators. Distributed estimation -Computational, communications, and controls resources in networked control systems-Distributed control- Convex Optimization - Optimization-based control design.
- **MULTI AGENT ROBOTICS**
  Formations - Graph rigidity -Persistence -Formation control, sensor and actuation models-distance based formations, rigidity, position based formations, formation infeasibility - Consensus problem- static, dynamic, distributed estimation, leader-follower architectures for consensus-Reaching decentralized agreements through cooperative control- leader-follower networks-Network controllability- Network feedback- Averaging Systems-Positive Systems-nonholonomic, double integrator, rigid body dynamics-Collision avoidance: potential fields, navigation functions. Introduction to artificial intelligence & deep learning for multi-agent robotics.
- **MOBILE SENSOR AND COMMUNICATION NETWORKS**
  Sensor networks: Coverage control- Coverage and detection problems-Gabriel and Voronoi graphsvoronoi-based cooperation strategies-Random graphs - LANdroids: Communication networks - Communication models- mobile communications networks- connectivity, connectivity maintainance, sampling, delays, packet losses, quantization, security -Swarming-

sensor networks: sensing constraints, aggregation, dispersion, coverage control, deployment, flocking. Internet of things (IOT).

3. Books Recommended:

1. Mehran Mesbahi and Magnus Egerstedt, ‘Graph Theoretic Methods in Multiagent Networks,’ Princeton University Press, 2010.
2. F. Bullo, J. Cortes, and S. Martinez, ‘Distributed Control of Robotic Networks’, Princeton, 2009.
3. C. Godsil and G. Royle, ‘Algebraic Graph Theory’, Springer, 2001.
4. P. J. Antsaklis and P. Tabuada,, ‘Networked Embedded Sensing and Control’, Springer 2006.
5. C. Godsil and G. Royle, ‘Algebraic Graph Theory’, Springer, 2001.

M. Tech. (Electrical)(C&A), Ist year, Semester II

L	T	P	Credit
3	0	0	03

ADVANCED COMMUNICATIONS

ELCA120

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Describe the basic knowledge of data communication methods, centralized/distributed networking architectures, OSI reference model, networking issues, protocols
CO2	Illustrate the suitable network protocols at various layers in computer networks along with the constraints
CO3	Apply the protocols and techniques in developing the standard networks using standard tools or software overcoming the constraints
CO4	Analyze the performance of various techniques and protocols in a given network topology, case study and problem solving as per given data.
CO5	Design the codes for the given protocols using appropriate tools

2. Syllabus

- **DATA COMMUNICATION AND NETWORKING OVERVIEW**
  A Communication Model, Data Communication, Networking Concept, Topology and Transmission Media, Subnet, Concept of Client and Server, An Example Configuration, The Need for Protocol Architecture, Protocol Architecture and peer processes, OSI Reference Model, The TCP/IP Protocol Stack.
- **DATA LINK CONTROL**
  Medium Access Control (MAC) And Logical Link Control (LLC) Sublayer Issues, Flow Control, Error Control, Access Control, Sliding Window Protocol, Polling, High-Level Data Link Control (HDLC), PPP, Performance Issues.
- **LOCAL AREA NETWORKS — OVERVIEW**
  LAN Protocol Architecture, Bridges, Emergence of High-Speed LANs, Ethernet, Wireless LAN Technology (Wi-Fi) Protocols.
- **ROUTING AND CONGESTION CONTROL**
  Logical Addresses, Circuit-Switching and Packet Switching Networks, Classful Addressing, Classless Addressing (CIDR), Subnetting, Super netting, Network Address Translation, Routing In Packet-Switching Networks, Broadcasting, Multicasting, Flooding, Routing Algorithms, Effects Of Congestion, Congestion Control In Packet-Switching Networks. IP address classes, Ad-Hoc network Routing constraints. Mobile IP and its architecture
- **INTERNETWORK PROTOCOLS**
  Basic Protocol Functions, Principles of Internetworking, Fragmentation Concept, Connectionless Internetworking, Gateway and Routers, The Internet with IPv4 and IPv6 packet formats, ARP, RARP, DHCP, ICMP, IGMP.
- **TRANSPORT PROTOCOLS**
  Port Addresses, Quality of Service Parameter, TCP, UDP and SCTP Protocols Mobile TCP

- **NETWORK SECURITY**
  Security Requirement and Attacks, Cryptography, Classical Ciphers, Modern Ciphers, Confidentiality with Encryption, Message Authentication And Hash Functions, Public-Key Encryption And Digital Signatures
- **DISTRIBUTED APPLICATIONS**
  Network Virtual Terminal (TELNET), File Transfer Protocol (FTP), Electronic Mail - SMTP And MIME, Hyper Transfer Protocol (HTTP), Network Management - SNMP, Domain Name Server (DNS), URL, WWW.

3.Books Recommended:

1. Tanenbaum Andrew S., "Computer Networks", PHI, 5th Ed., 2011.
2. Stalling William, "Data and Computer Communications", PHI, 10th Ed., 2014.
3. Forouzan Behrouz A., "Data Communications and Networking", Tata McGraw-Hill, 5th Ed., 2013.
4. Gallager R. G. And Bertsekas D., "Data Networks", PHI, 2nd Ed., 1992.
5. Garcia Leon and Wadjaja I., "Communication Networks", Tata McGraw-Hill, 2nd Ed., 2004.

ELECTIVE IV

M. Tech. (Electrical)(C&A), Ist year, Semester II

L	T	P	Credit
3	0	0	03

GUIDANCE AND FLIGHT CONTROL SYSTEM

ELCA122

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Derive equations of motion of an aircraft and analyze its stability
CO2	Understand the principles of navigation and various sensors used
CO3	Understand, design, and implement various guidance laws
CO4	Understand, design, and implement the integration of state estimation with guidance and control
CO5	Case studies with simulation for guidance problems defined in two and three dimensions

2. Syllabus

- **Equations of Motion and Rigid Body Dynamics**
  Equations of Motion: rigid body dynamics, coordinate transformation, Euler angle & quaternion formulation, Dynamics of Generic Fixed Wing Aircraft: 6-DoF equations of motion, linearized equations of motion, linearized longitudinal & lateral equations, aerodynamic derivatives, LTI system basics, Stability of Uncontrolled Motion: linearized longitudinal & lateral dynamics, modes of motion, Response to Control Inputs: transfer function, step response & frequency response characteristics, Feedback Control: stability augmentation, PID control, root-locus technique for controller design, State-space formulations.
- **Principles of Navigation**
  Navigation: Principles of Inertial Navigation: Components, two-dimensional navigation, Coordinate systems, 3D strapdown navigation system, Strapdown system mechanizations, Attitude representation, Navigation equations expressed in component form, Effects of elliptic earth, Inertial Sensors: Gyroscope principles, single-axis rate gyroscope, accelerometers, rate integrating gyroscope.
- **Guidance and Control**
  Guidance and Control: Elements of guidance system, Guidance phases, Guidance trajectories, Guidance sensors, Classification of Guidance and Navigation Systems: Basic navigation systems, combined navigation systems, Classification of guidance systems: Three-point tactical guidance laws, Two-point Tactical Guidance Laws: Strategic guidance laws, pursuit, LOS and PN laws, Guidance of UAVs; Control: Linear time-invariant systems, transfer functions and state space modeling, analysis and synthesis of linear control systems, applications to aerospace engineering.
- **Introduction to Autopilot; simulation studies**
  Introduction to Autopilot and design, integration of linear and non-linear state estimators with guidance laws. Case studies involving simulations in two and three dimensions.

3. Books Recommended:

1. Anderson, J. D., Aircraft Performance and Design, Tata McGraw-Hill (1998)
2. Siouris, G. M., Missile Guidance and Control Systems, AIAA (2004)
3. Zarchan, P., Tactical and Strategic Missile Guidance, AIAA Publications, 4th Edition, (2002)
4. Nise, N. S., Control Systems Engineering, Wiley India (2004)

M. Tech. (Electrical)(C&A), Ist year, Semester II

L	T	P	Credit
3	0	0	03

IMAGE PROCESSING

ELCA124

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Discuss Fourier transform for image processing in frequency domain and compare the image compression techniques in spatial and frequency domains.
CO2	Apply techniques for image enhancement both in spatial and frequency domains.
CO3	Analyze causes for image degradation and apply restoration techniques.
CO4	Evaluate different image segmentation techniques.
CO5	Develop solutions using morphological concepts.

2. Syllabus

- **INTRODUCTION DIGITAL IMAGE FUNDAMENTALS**
  Digital Image, Image Processing origins; Imaging in X-Rays, Ultraviolet, Visible Infrared, Visible, Microwave and Radio Bands; Fundamentals of Image Processing; Components of Image Processing Systems.
  Visual Perception — Human Eye, Brightness Adaptation and Discrimination, Electromagnetic Spectrum; Image Sensing and Acquisition — Single, Strip and Array Sensors, Image Formation Models; Image Sampling and Quantization — Basic Concepts, Representation of Image, Special and Gray Level Resolution, Aliasing, Zooming and Shrinking; Relationships Between Pixels-Nearest Neighbor, Adjacency, Connectivity, Regions, and Boundaries; Distance Measures; Image Operations on a Pixel Basis; Linear and Nonlinear Operations.

- **IMAGE ENHANCEMENT**
  Gray Level Transformations-Image Negatives, Log, Power-Law and Piecewise Linear Transformation Functions; Histogram Processing -Equalization, Matching; Enhancement Operations - Arithmetic, Logic, Subtraction and Averaging; Spatial Filtering -Linear and Order-Statistics for Smoothing, First and Second Derivatives/Gradients for Sharpening, 2-D Fourier Transform, Its Inverse and Properties; Discrete and Fast Fourier Transform; Convolution and Correlation Theorems; Filtering in Frequency Domain - Low Pass Smoothing, High Pass Sharpening, Homomorphic Filtering.
- **IMAGE RESTORATION AND COMPRESSION**
  Image Degradation and Restoration Processes; Noise 'Models - Spatial Properties, Noise Probability Density Functions, Periodic Noise, Estimation Of Noise Parameters; Restoration in the Presence Of Noise and Mean Filters, Order-Statistics Filters, Adaptive Filters; Linear Position-Invariant Degradations and Estimation; Geometric Transformations - Spatial Transformation, Gray-Level Interpolation.
  Fundamentals of Compression, Image Compression Model, and Error free Compression, Lossy Predictive Coding, and Transform Coding.

- **MORPHOLOGICAL IMAGE PROCESSING**
  Preliminaries-Set Theory and Logic Operations in Binary Images; Basic Morphological Operations - Opening, Closing Operators, Dilation and Erosion, Morphological Algorithms - Boundary Extraction, Region Filling, Extraction of Connected Components, Convex Hull, Thinning, Thickening, Skeletons; Extension of Morphological Operations to Gray-Scale Images.

- **IMAGE SEGMENTATION, REPRESENTATION AND DESCRIPTION**
  Detection of Discontinuities - Point, Line and Edges; Edge Linking and Boundary Detection, Local Processing, Global Processing Using Hough Transform; Thresholding - Local, Global and Adaptive; Region-Based Segmentation - Region Growing, Region Splitting and Merging; Motion Detection.
  Representations - Chain Codes, Polygonal Approximations, Signatures, Boundary Segments, Skeletons; Boundary Descriptors - Shape Numbers, Statistical Moments; Regional Descriptors - Topological, Texture and Moments Of 2-D Functions

3. Books Recommended:

1. Gonzalez R. C. and Woods R. E, "Digital Image Processing", 3rd Ed., Pearson Prentice Hall, 2008.
2. Sonka M. Hlavac V., Boyle R., "Image Processing, Analysis and Machine Vision", Cengage Learning, 2nd Ed. Indian Reprint, 2009.
3. Jain R., Kasturi R. and Schunk B., "Machine Vision", 1st Ed., McGraw - Hill, 1995.
4. Jain A. K., "Fundamentals of Digital Image Processing", 1st Ed., PHI, 1989.
5. W Pratt, “Digital Image Processing”, Wiley, 2001

M. Tech. (Electrical)(C&A), Ist year, Semester II

L	T	P	Credit
3	0	0	03

ROBOTICS AND AUTOMATION

ELCA126

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Discuss need and anatomy of industrial robots
CO2	Apply the forward kinematics, inverse kinematics and dynamics for serial and parallel robots
CO3	Analyze the manipulator including actuator, drive and sensor issues
CO4	Analyze the robot cell design for different applications
CO5	Discuss various robot programming methods and need of Artificial Intelligence in robotic applications

2. Syllabus

- **INTRODUCTION AND ROBOT KINEMATICS**
  Definition, need and scope of industrial robots, robot anatomy, work volume, precision movement, end effectors, sensors. Robot kinematics: direct and inverse kinematics, control of robot manipulators, robot dynamics.
- **ROBOT DRIVES AND CONTROL**
  Controlling the robot motion, position and velocity sensing devices, design of drive systems, hydraulic and Pneumatic drives, linear and rotary actuators and control valves, electro hydraulic servo valves, electric drives, Motors, designing of end effectors, vacuum, magnetic and air operated grippers.
- **ROBOT SENSORS**
  Transducers and sensors, sensors in robot, tactile sensor, proximity and range sensors, sensing joint forces, robotic vision system, Image grabbing, image processing and analysis, image segmentation, pattern recognition, training of vision system.
- **ROBOT CELL DESIGN AND APPLICATION**
  Robot work cell design and control, safety in robotics, robot cell layouts, multiple robots and machine interference, robots cycle time analysis, industrial application of robots.
- **ROBOT PROGRAMMING AND ARTIFICIAL INTELLIGENCE**
  Methods of robot programming, characteristics of task level languages lead through programming methods, motion interpolation, artificial intelligence, basics, goals of artificial intelligence, AI techniques, problem representation in AI, problem reduction and solution techniques, application of AI in Robots.

3. Books Recommended:

1. Fu K. S., Gonzalez, R. C. and Lee, C. S. G., Robotics: Control, Sensing, Vision and Intelligence, McGraw Hill, 1987.
2. Richard, D, Klafter, Thomas, A, Chmielowski, Michael Negin, Robotics Engineering: an Integrated approach, PHI, 1987.
3. J. Norberto Pires, Industrial Robots Programming: Building Applications for the Factories of the Future, Springer, 2007.
4. Rex Miller, Mark R. Miller, Robots and Robotics: Principles, Systems, and Industrial Applications, McGraw Hill, 2017.
5. Mark W Spong, M. Vidyasagar , Robot Dynamics and Control, Wiley India Pvt. Limited, 2008.

M. Tech. (Electrical)(C&A), Ist year, Semester II

L	T	P	Credit
3	0	0	03

ADVANCED CONTROL AND INSTRUMENTATION

ELCA128

1.Course Outcomes (COs):

At the end of the course, the students will be able to:

Understand the concepts of multiple input multiple output systems	
Analyze the control-loop interactions of MIMO systems and analyze the sensitivity	
Design control strategy for MIMO systems based on multi-variable SISO framework	
Learn the working and characteristics of transducers and sensors	
Learn various interfacing techniques and standards for communication between instruments	

2.Syllabus

ENHANCEMENTS TO FEEDBACK CONTROLLERS

PID enhancements, Antireset windup, Autotuning techniques, Nonlinear PID controller, Gain scheduling, Ratio control, Selective and Override control, Spit-Range control, Limitation of feedback control, Cascade-control analysis and design, Cascade control based IMC and direct synthesis, Feed-Forward control analysis, and design, Combined Feed-Forward and Cascade control

MULTIVARIABLE SYSTEMS AND CONTROL-LOOP INTERACTION

MIMO systems, motivating examples, Control-loop interaction, general pairing problem, relative gain array (RGA), Properties and applications of RGA, RGA and sensitivity, Using RGA to determine variable pairings through illustrative examples.

MULTIVARIABLE CONTROL

Transmission zeros and subsequent performance limitations, calculation and illustration, Directional sensitivity and operability, Singular value decomposition, Decoupling: ideal, simplified and static decoupling, Feedback control using decoupling. IMC design procedure for MIMO systems. Implementation and analysis of benchmark control problems. Model Predictive Control, Dynamic matrix control.

FINAL CONTROL ELEMENTS AND SENSORS

Pneumatic control valves, construction, types, characteristics and other final control elements. Differential pressure transmitter, rotameter and other sensors. Choice of sensors and their technical specifications for various industrial and laboratory scale processes such as quadruple tank sytem, coupled-tank system, Magnetic levitation system etc.

MODERN SENSORS AND INTERFACING

Optical sensors, positioning sensors, distance and thickness sensors, micro-miniaturized sensing devices (MEMS), ultrasonic sensors, IR temperature detection, distributed fiber optic sensors, radio frequency tagging (RFID), intelligent sensors standard and protocols, introduction to wireless sensor network and protocols. Digital data communication, open system interconnection (OSI model), Data communication methodology, overview of EIA RS 232, RS

485 interface standard, 4-to-20mA current loop serial communication, Modbus protocol, overview of Industrial Ethernet & TCP/IP

3.Books Recommended:

1. Dale E. Seborg, Thomas F. Edgar, Duncan A. Mellichamp, Francis J. Doyle III, Process Dynamics and Control, 3rd Edition, John Wiley & Sons, Inc., 2011.

2. B. Wayne Bequette, Process Control: Modeling, Design, and Simulation, Prentice Hall, Prentice Hall, 2003.

3. Curtis D. Johnson, Process Control Instrumentation Technology, 8th Edition, Pearson Education India, 2015.
4. Ernest O Doeblin, Measurement Systems: Application and Design, McGraw Hill (Int. edition) 1990.

INSTITUTE ELECTIVE

M. Tech. (Electrical)(C&A), Ist year, Semester II
AUTOMOTIVE CONTROL SYSTEMS

L	T	P	Credit
3	0	0	03

ELCA172

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1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Discuss need of automotive control systems
CO2	Comprehend basic Engine Operation and various aspects of engine control system
CO3	Explain driveline modeling and control
CO4	Calculate various vehicle parameters
CO5	Perform state estimation and vehicle dynamics control

2. Syllabus

- **Automotive Engine modeling an driveline control**
  Introduction to automotive systems, need of control systems for automobiles and a brief history of automotive control systems, engines and working principle, engine operation and engine control. Engine Control Systems: Lambda Control; Speed Control; Knock Control; Cylinder Balancing

  Driveline Control: Driveline modeling, Modeling of neutral gear, state space modeling of driveline control; Driveline control with LQG / LTR; Driveline control for speed, control for gear shifting and anti-jerk control of passengers.

- **Vehicle Dynamics Modeling, estimation and control**
  Wheel Model, Complete Vehicle Model, Vehicle parameters and states. Estimation of vehicle velocity and Yaw rate, trajectory reconstruction, identification of vehicle parameters and its approximation, Observers, Kalman filters, Body Side Slip Angle observer, determination of road gradient. Vehicle Control Systems: ABS control systems, control of Yaw Dynamics, road and driver models. Modeling of automotive control systems in MATLAB/SIMULINK environment.

3. Books Recommended:

1. U. Kiencke and L. Nielsen, "Automotive Control Systems: For Engine, Driveline, and Vehicle," Springer-Verlag New York, LLC, 2004.
2. Shahram Azadi , Reza Kazemi, Hamidreza Rezaei Nedamani, “Vehicle Dynamics And Control Advanced Methodologies”, Elsevier Ltd. 2021

M. Tech. (Electrical)(C&A), I year, Semester II

MODERN INDUSTRIAL DRIVES AND AUTOMATION

L	T	P	Credit
3	0	0	03

ELCA174/EEPE174

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Understand the modern industry drive and its installation and connections
CO2	Apply the various parameter setting
CO3	Explain the need of industrial automations
CO4	Develop the ladder logic for various industrial applications
CO5	Design the scheme to operate drive with PLC

2. Syllabus

- **MODERN INDUSTRIAL DRIVES**
  Introduction, Applications of modern industrial drive, specification of Modern Industrial Drives, Installation, connections- control and power terminals, commissioning, parameter setting, open loop and close loop speed control, change of acceleration and de-acceleration time, over speeding, forward/reverse operating with operating two drive in synchronism, sensor less speed control, speed control with encoder, useof digital inputs and outputs of drive.
- **INDUSTRIAL AUTOMATION**
  Need for an industrial automation, PLC definition, overview of PLC systems, input/output modules, power supplies and isolations. General PLC programming procedures, programming on-off inputs/ outputs, Bit logic, data move, timers, counters, compare, convert instructions. Arithmetic instructions. Analog value processing. Generation of Analog output to control drive, control of drive with digital output of PLC. Speed variation of industrial drive with digital and analog output of PLC.

3. Books Recommended:

1. G.K.Dubey, Fundamentals of Electrical Drives, Narosa- 1995.
2. S.A. Nasar, Boldea , Electrical Drives, Second Edition, CRC Press – 2006.
3. M. A. ElSharkawi , Fundamentals of Electrical Drives , Thomson Learning -2000.
4. John W. Webb and Ronald A. Reis, Programmable Logic Controllers - Principles and Applications, Fourth edition, Prentice Hall Inc., New Jersey, 1998.
5. Frank D. Petruzella, Programmable Logic Controllers, Second edition, McGraw Hill, New York, 1997.

M. Tech. (Electrical)(C&A), Ist year, Semester II

OPTIMIZATION IN CONTROL AND AUTOMATION

L	T	P	Credit
3	0	0	03

ELCA176

1.Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Apply mathematical and numerical techniques of optimization theory to concrete Engineering problems.
CO2	Apply mathematical and numerical techniques of optimization theory to concrete Engineering problems.
CO3	Describe the mathematical properties of general linear programming problems and obtain the solution of linear programming problems using appropriate techniques.
CO4	Formulate real-world problems as Linear Programming models, apply the simplex method and dual simplex algorithms in solving the standard LP problem and interpret the results obtained.
CO5	Apply linear programming in various engineering applications

2.Syllabus

- **LINEAR PROGRAMMING**
  Concepts of optimization: Engineering applications, Statement of optimization problem, Classification - type and size of the problem. Classical Optimization Techniques: Single and multivariable problems-Types of Constraints. Semi definite case-saddle point. Linear programming: Standard Form-Geometry of LP problems-Theorem of LP-Relation to convexity - formulation of LP problems - simplex method and algorithm -Matrix form- two phase method. Duality-dual simplex method- LU Decomposition. Sensitivity analysis. Artificial variables and complementary solutions-QP. Engineering Applications: Minimum cost flow problem, Network problems-transportation, assignment & allocation, scheduling.
- **NONLINEAR PROGRAMMING**
  Nonlinear programming: Non linearity concepts-convex and concave functions- non-linear programming - gradient and Hessian. Unconstrained optimization: First & Second order necessary conditions-Minimization &MaximisationLocal& Global Convergence-Speed of convergence. Basic decent methods: Fibonacci & Golden section search - Gradient methods - Newton Method Lagrange multiplier method - Kuhn-tucker conditions. Quasi-Newton method- separable convex programming - Frank and Wolfe method, Engineering Applications.
- **CONSTRAINED NONLINEAR PROGRAMMING**
  Nonlinear programming- Constrained optimization: Characteristics of constraints-Direct methods SLP, SQP-Indirect Methods-Transformation techniques-penalty function-Lagrange multiplier methods checking convergence- Engineering applications.
- **DYNAMIC PROGRAMMING**
  Dynamic programming: Multistage decision process- Concept of sub optimization and principle of optimality- Computational procedure- Engineering applications. Genetic algorithms- Simulated Annealing Methods-Optimization programming, tools and Software.

3.**Books Recommended:**

1. David G Luenberger, 'Linear and Non-Linear Programming'., 2nd Ed, Addison-Wesley Pub.Co., Massachusetts, 2003.
2. W.L.Winston, 'Operation Research-Applications & Algorithms',2nd Ed., PWS-KENT Pub.Co.,Boston, 2007.
3. S.S.Rao, 'Engineering Optimization'., 3rd Ed., New Age International (P) Ltd,New Delhi, 2007.
4. W.F.Stocker, 'Design of Thermal Systems', 3rd Ed., McGraw Hill, New York. 1990.
5. G.B.Dantzig, 'Linear Programming and Extensions'. Princeton University Press, N.J., 1963.

M. Tech. (Electrical)(C&A), Ist year, Semester II

L	T	P	Credit
3	0	0	03

SMART GRIDS

ELCA178

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Get acquainted with the smart resources, smart meters and other smart devices
CO2	Describe how modern power distribution system functions
CO3	Identify suitable communication networks for smart grid applications
CO4	Formulate economic load dispatch problem as constrained optimization problem
CO5	Formulate and solve nonlinear and dynamic programming problems

2. Syllabus

- **INTRODUCTION**
  Introduction, Evolution of Electric Grid, Smart Grid Concept, Need for Smart Grid, Functions, Opportunities, Benefits and challenges, Difference between conventional & Smart Grid,Technology Drivers, Indian smart grid, Key challenges for smart grid.
- **SMART DEVICES**
  Energy Management System (EMS), Smart substations, Substation Automation, Feeder Automation, SCADA, Remote Terminal Unit, Intelligent Electronic Devices, Phasor Measurement Unit in wide area monitoring protection and control, Smart integration of energy resourceswithrenewable, intermittent power sources, Energy Storage, Distribution Management System (DMS) (Volt / VAR control), Fault Detection, Isolation and Service Restoration, Network Reconfiguration, Outage management System, Customer Information System, Geographical Information System, Effect of Plug in Hybrid Electric Vehicles.
- **OPTIMIZATION TECHNIQUES FOR SMART GRID**
  Nonlinear programming, Constrained optimization: Characteristics of constraints, Direct methods such as SLP,SQP, Indirect methods, Transformation techniques like penalty function-Lagrange multiplier methods checking convergencefor power applications such as Economic load dispatch.
- **DYNAMIC PROGRAMMING**
  Dynamic programming: Multistage decision process, Concept of sub optimization and principle of optimality, Genetic algorithms, Simulated Annealing Methods, Optimization programming, tools and Software packages, Artificial Intelligence techniques and applications in power systems.

3. Books Recommended:

1. Stuart Borlase , Smart Grid: Infrastructure, Technology and Solutions, CRC Press 2012.
2. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, Smart Grid:Technology and Applications, Wiley, 2012.
3. Mini S. Thomas, John D McDonald, Power System SCADA and Smart Grids, CRC Press, 2015.
4. Kenneth C.Budka, Jayant G. Deshpande, Marina Thottan, Communication Networks for SmartGrids, Springer, 2014.

L	T	P	Credit
3	0	0	03

M. Tech. (Electrical)(C&A), Ist year, Semester II

Instrumentation-based System Design

ELCA180

1.Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Carry out research and development in the area of advanced instrumentation and signal conditioning.
CO2	Be well-versed with the sensor characteristics, basic signal conditioning circuits and sensor interfaces
CO3	Analyze and design different kinds of signal amplifiers, their non-idealities, and performances
CO4	Analyze and design noise and interference reduction circuits and improve the system performance
CO5	Solve practical and state-of-the-art problems related to sensor interfacing circuits and serve the related industries

2.Syllabus

- **INTRODUCTION**
  Instrumentation and measurement system, Sensors, Primary sensing principles, Sensor performance characteristics, Sensor interfacing and signal conditioning circuit, integrated sensor system.
- **SIGNAL CONDITIONING CIRCUITS**
  Signal conditioning circuits for resistive, capacitive, and inductive sensors, electromagnetic and self-generating sensors, Error and Non-linearity reduction, Differential measurements.
- **SIGNAL AMPLIFIERS**
  Non-idealities of Op-Amp, Effect of Non-idealities, Differential Amplifier, Trans-impedance Amplifier, Cascaded Amplifiers, CMRR, Performance Analysis of Amplifiers, Instrumentation amplifier, Charge amplifier, Programmable gain amplifier, Switched Capacitor amplifier.
- **INFERENCE AND NOISE**
  Interference types and reduction, Signal circuit grounding, Shield grounding, and isolation amplifier. Types of Noise and Noise Sources, Offset and Noise reduction techniques: Auto-zeroing (AZ), Chopper-stabilization (CHS), Correlated double sampling (CDS), Sigma-Delta modulation
- **PACKAGING AND INTEGRATION**
  Packaging and Encapsulation, Die and wafer level bonding, Types of packages, Sensor and Circuit integration: PCB, hybrid, monolithic, SOC and SIP.

3.**Books Recommended:**

1. Ramon Pallas-Areny and John G. Webster, Sensors and Signal Conditioning, Wiley India Pvt Ltd, 2nd Edition, 2012
2. Ramon Pallas-Areny and John G. Webster, Analog Signal Processing, Wiley India Pvt Ltd, 2nd Edition, 2012
3. Anton F. P. van Putten, Electronic Measurement Systems, Theory and Practice, IOP Publishing, 2nd Edition, 1996
4. Jacob Fraden, Handbook of Modern Sensors- Physics, Designs, and Applications, Springer, Fourth Edition, 2010

M. Tech. (Electrical)(C&A), Ist year, Semester II

SYSTEM IDENTIFICATION AND ADAPTIVE CONTROL

L	T	P	Credit
3	0	0	03

ELCA182

1Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Discretize continuous time system and understand sampling theorem
CO2	Acquire knowledge of various plant and disturbance models
CO3	Implement various estimation algorithms to identify system models
CO4	Analyze stability of equilibrium points
CO5	Design model reference adaptive and robust adaptive controllers

2 Syllabus

- **INTRODUCTION**
  Motivation and overview of System Identification, Models of discrete time linear time invariant systems, Difference equation, Transfer functions, State space models, Discretization, Sampling and hold operations, Sampling theorem.
- **PLANT AND DISTURBANCE MODELS**
  Impulse response, Step response and frequency response models, Disturbance models-random processes, Representation of stationary processes, White noise process, Auto-covariance function, ARMA models, Parametric model structures-ARX, ARMAX, OE, BJ, and PEM structures.
- **ESTIMATION OF MODELS**
  Least square estimates, Statistical properties of LS estimates, Weighted least squares, Recursive least squares, Maximum likelihood estimation, Estimation of non-parametric models, Estimation of parametric models.
- **STABILITY OF EQUILIBRIUM POINTS**
  Need for adaptive controllers, Stability of Equilibrium points, Asymptotic stability, Uniform stability, Lyapunov stability theorems, Lyapunov's direct method, Signal norms, Barbalat's Lemma.
- **ADAPTIVE CONTROL**
  Effects of process variations, adaptive schemes, adaptive control problems, Deterministic self tuning regulators, pole-placement design, Indirect self-tuning regulators, continuous-time self tuners, direct self-tuning regulators. Model-reference adaptive systems, MIT rule, determination of adaptive gain, design of MRAS using Lyapunov theory

3 Books Recommended:

1. Lennart Ljung, System Identification, Prentice Hall, 1999.
2. T. Soderstrom and P. Stoica, System Identification, Prentice Hall International, 1994.

3. Arun K. Tangirala, Principles of System Identification, CRC Press, 2015.
4. K. J. Astrom and B. Wittenmark, Adaptive Control, Dover Publications INC., New York, 2008.
5. J.J.E. Slotine, and W. Li, Applied Nonlinear Control, Prentice-Hall, 1991.

M. Tech. (Electrical)(C&A), 1st year, 2nd Semester

ADVANCEDINDUSTRIAL AUTOMATION TRAINING/ADVANCED INDUSTRIAL AUTOMATION PROFESSIONAL EXPERIENCE

ELCAV92/ELCAP94 (5 credits, 10 hours)

Supervisory control and data acquisition / human machine interface, introduction to SCADA, role of SCADA in industrial automation.

SCADA: network communications & communication with RTUs, analog/digital, communications on plant floors, communication standards / OPC server (OLE for process control)/PLC (RTU), and SCADA Interface configuration concepts.

SCADA system configuration, RTU, communication protocols, script programming, real time and historical trends, configuring alarms, real time project development with PLC interfacing, communication with other softwares.

PROPOSED CURRICULUM AND SYLLABUS

FOR

M. TECH

IN

COMMUNICATION SYSTEMS

DEPARTMENT of ELECTRONICS ENGINEERING
SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY
ICHCHHANATH, SURAT-395 007

SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY (SVNIT-Surat), SURAT

VISION

To be one of the leading Technical Institutes disseminating globally acceptable education, effective industrial training and relevant research output.

MISSION

To be a globally accepted centre of excellence in technical education catalyzing absorption, innovation, diffusion and transfer of high technologies resulting in enhanced quality for all the stake holders.

DEPARTMENT OF ELECTRONICS ENGINEERING

MISSION

The mission of the Department of Electronics Engineering is to contribute to society and industry through excellence in education, research, innovations, and ethics by stakeholders.

VISION

The vision of the Department of Electronics Engineering is to aim to achieve quality in education and research to create leading Electronics engineers, researchers, and entrepreneurs.

DEPARTMENT OF ELECTRONICS ENGINEERING
SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY
ICHCHHANATH, SURAT-395 007

M. Tech. Programme in

COMMUNICATION SYSTEMS

Program Educational Objectives (PEOs):

1. Graduates formulate, analyse and solve real-life engineering problems applying the basic knowledge of Electronics Engineering. (**Knowledge**)
2. Graduates become researcher or design professionals for sustainable state of the art products as per market trends. (**Skill**)
3. Graduates take gainful employment for manufacturing functions or do the technology transfer or develop the industry. (**Technical Contribution-Industry**)
4. Graduates become entrepreneurs in engineering sector or involve in spreading his skill and experience globally. (**Technical Contribution - Society**).

Program Outcomes (POs):

PO1:	To carry out multidisciplinary research / Investigations and complex real life problems solving capability
PO2:	To write and present a substantial technical report/research article
PO3:	To Demonstrate a higher level of professional skills over the areas of advanced communication technologies and networks
PO4:	To Apply appropriate methodology and modern engineering/IT tools to meet the international standards in the area of advanced communication technologies and networks
PO5:	To inculcate research attributes and approach through industry oriented internships and projects.(Team work and Finance management)
PO6:	To perform environment supportive professional and ethical responsibility of the society.
PO7:	To engage in self-improvement through continuous professional development and life-long learning.

MAPPING OF POs & PEOs:

	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**
PEO-1	03	03	02	03	02	02	02
PEO-2	03	03	02	03	03	02	01
PEO-3	02	02	03	03	03	01	03
PEO-4	01	01	01	01	01	03	03

Course Structure and Scheme of Evaluation (Semester wise)

M. Tech in Communication Systems

M.Tech. I (EC), Semester I (Communication System)												
Sr. No.	**Course Name**	**Code**	**Teaching Sch.**			**Credit**	**Examination Scheme**				**Notional hours of Learning (Approx.)**
			Th	**T**	**P**		**Th**	**T**	**P**	**Total**	
1	Core Subject-1 RF Circuits & Systems	ECCS101	3	0	0	03	100	--	--	100	55
2	Core Subject-2 Advance Optical Communication Systems	ECCS103	3	0	0	03	100	--	--	100	55
3	Core Subject-3 Advance DSP	ECCS105	3	0	0	03	100	--	--	100	55
4	Elective-I	ECCS1XX	3	0	0	03	100	--	--	100	55
5	Elective-II	ECCS1XX	3	0	0	03	100	--	--	100	55
6	Communication Lab-I	ECCS107	0	0	6	03	--	--	150	150	100
7	Seminar	ECCS109	0	0	4	02			100	100	70
		Total	**15**	**0**	**10**	**20**	**500**	**--**	**250**	**750**	**445**
Total Contact Hours per week: 25											

M.Tech. I (EC), Semester II (Communication System)											
Sr. No.	**Course Name**	**Code**	**Teaching Sch.**			**Credit**	**Examination Scheme**				**Notional hours of Learning (Approx.)**
			Th	**T**	**P**		**Th**	**T**	**P**	**Total**	
1	Core Subject-4 Image Processing and Computer Vision	ECCS102	3	0	0	03	100	--	--	100	55
2	Core Subject-5 Wireless Communication	ECCS104	3	0	0	03	100	--	--	100	55
3	Institute Elective*	ECCS1XX	3	0	0	03	100	--	--	100	55
4	Elective-IV	ECCS1XX	3	0	0	03	100	--	--	100	55
5	Elective-V	ECCS1XX	3	0	0	03	100	--	--	100	55
6	Communication Lab-II	ECCS106	0	0	6	03	--	--	150	150	100
7	Mini Project	ECCS108	0	0	4	02			100	100	70
		Total	**15**	**0**	**10**	**20**	**500**	**--**	**250**	**750**	**445**
Total Contact Hours per week: 25											

M.Tech. II(EC), Semester III (Communication System)											
Sr. No.	**Course Name**	**Code**	**Teaching Sch.**			**Credit**	**Examination Scheme**				**Notional hours of Learning (Approx.)**
			Th	**T**	**P**		**Th**	**T**	**P**	**Total**	
1	Dissertation Phase-1	ECCS201	-	-	28	14	-	-	350$	350	560
2	MOOC Course – I*	Ψ	-	-	-	3/4	-	-	-	-	70/80
3	MOOC Course – II*	Ψ	-	-	-	3/4	-	-	-	-	70/80
		Total	**-**	**-**	**28**	**20/ 22**	**-**	**-**	**350**	**350**	**700/ 720**
Total Contact Hours per week: 25 + NPTL* Courses											

M.Tech. II(EC), Semester IV (Communication System)											
Sr. No.	**Course Name**	**Code**	**Teaching Sch.**			**Credit**	**Examination Scheme**				**Notional hours of Learning (Approx.)**
			Th	**T**	**P**		**Th**	**T**	**P**	**Total**	
1	Dissertation Phase-2	ECCS202	-	-	40	20	-	-	600$	600	800
		Total	**-**	**-**	**40**	**20**	**-**	**-**	**600**	**600**	**800**
Total Contact Hours per week: 40											

- φ : As per 66th IAAC, Dated 20th March, 2024, Resolution No. 66.34 and 61st Senate resolution No. 4, 25th April, 2024

- $**Internal**: 40% and **External**: 60%

*NPTEL, SWAYAM and other Massive Open Online Course (MOOC) approved by DAAC

LIST OF SUBJECTS FOR ELECTIVE I & II: (Semester – I)		
(1)	Information Theory & Coding	ECCS111
(2)	Digital Satellite Communication	ECCS113
(3)	Cognitive Radio	ECCS115
(4)	Probability and Random Processes	ECCS117
(5)	Antenna Theory and Design	ECCS119
(6)	Machine learning and its Applications	ECCS121
(7)	Digital VLSI Design	ECVL101
(8)	Embedded Systems	ECVL105
(9)	Semiconductor IC Technology	ECVL111

LIST OF SUBJECTS FOR ELECTIVE III (INSTITUTE ELECTIVE) (Semester – II)		
(1)	Deep Learning, Theory and Practice	ECCS172
(2)	Internet of Things, Technologies and Applications	ECCS174

LIST OF SUBJECTS FOR ELECTIVE IV &V (Semester – II)		
(1)	Optical Networks	ECCS112
(2)	Estimation and Detection Theory	ECCS114
(3)	Microwave Integrated Circuits	ECCS116
(4)	Photonic Integrated Circuits	ECCS118
(5)	Ad-Hoc Networks	ECCS120
(6)	MIMO Technology	ECCS122
(7)	Global Navigation Satellite System	ECCS124
(8)	Optical Wireless Communication	ECCS126
(9)	5G Wireless Technologies	ECCS128
(10)	Speech Processing and Applications	ECCS130
(11)	Real Time Systems	ECVL104
(12)	VLSI Architecture for DSP	ECVL114

CORE COURSES: SEMESTER – I

M.Tech. I (Communication systems) Semester – I

RF Circuits And Systems

L	T	P	Credit
3	0	0	03

ECCS101 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe the Guided Wave solutions (TE, TM, and TEM), transmission line parameters and various components.
CO2	Classify the various active and passive components and circuits based on their design and working.
CO3	Use the appropriate portion of electromagnetic theory and its application to antennas
CO4	Analyse the transmission lines and their parameters using the Smith Chart, radiation principle of antennas, MIC components and circuits.
CO5	Evaluate the resonance frequency of cavity Resonators and the associated modal field.

2. Syllabus:

INTRODUCTION **(02 Hours)**

Circuit-Field Relations, RF Behavior of Passive Components, Chip Components.

TRANSMISSION LINE ANALYSIS **(10 Hours)**

Transmission line equations. Voltage and current waves. Solutions for different terminations. Transmission-line loading. Impedance transformation and matching. Smith Chart, Quarter-wave and half-wave transformers, the Multiple Reflection Viewpoint, Binomial and Tchebeyshev transformers. Single and double stub matching.

SINGLE- AND MULTIPORT NETWORKS **(02 Hours)**

Basic Definitions, Interconnecting Networks, Network Properties and Application, Scattering Parameters- Definition and Meaning of S- Parameters.

RF FILTERS DESIGN **(07 Hours)**

Basic Resonator and Filter Configurations, Special Filter Realizations.

MICROWAVE WAVEGUIDES AND COMPONENTS **(07 Hours)**

Introduction, Rectangular Waveguides, Rectangular Cavity Resonators, Circular waveguides, radiation from rectangular and circular apertures, Radiation from sectoral and pyramidal horns.

POWER DIVIDERS AND DIRECTIONAL COUPLERS **(05 Hours)**

The T Junction Power Divider, The Wilkinson Power Divider, The Quadrature (90°) Hybrid, Coupled Line Directional Couplers.

RADIATION **(06 Hours)**

Potential functions and the electromagnetic field, Oscillating electric dipole- derivations for E and H field components in spherical coordinate systems, Power Radiated by a current element, Application to antennas, Radiation from quarter wave monopole and half wave dipoles, Derivation for radiation resistance, application of reciprocity theorem to antennas, equality of directional patterns and effective lengths of transmitting and receiving antennas, directional properties of dipole antennas, antenna feeding methods. Antenna parameters and definitions.

MICROSTRIP ANTENNAS **(06 Hours)**

Basic characteristics of microstrip antennas, feeding methods, methods of analysis, design of rectangular and circular patch antennas.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Ludwig Reinhold and Bretchko Powel, "RF Circuit Design", Pearson Education, Reprint 2004
2. Pozar M. David, "Microwave Engineering", John Wiley & Sons, Inc., 1999
3. Liao Samuel, "Microwave Devices and Circuits". Pearson Education, Second Reprint, 2006
4. Bhat Bharathi and Koul Shibon,"Stripline Like Transmission Lines For MIC", New Age International, Reprint 2003.
5. C. A. Balanis, "Antenna Theory and Design", 3rd Ed., John Wiley & Sons., 2005.

M.Tech. I (Communication systems) Semester – I

Advance Optical Communication Systems

L	T	P	Credit
3	0	0	03

ECCS103 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Understand how light transmission occurs in fiber with different effects.
CO2	Classify, characterize and compare the different types of effects in fiber, passive and active optical components.
CO3	Apply/ Analyse the concepts of light transmission in SMF/WDM optical communication system and analyse effect of operational parameters in fiber, optical components, link and WDM system.
CO4	Estimate and evaluate fiber link and its design parameters.
CO5	Design optical communication systems.

2. Syllabus:

REVIEW OF FIBER OPTIC COMMUNICATION (06 Hours)

Elements Of Fiber Optic Communication, Light Transmission Basics, Optical Spectrum, Propagation Of Light In Fiber, Types of Fiber, Attenuation, Dispersion.

PASSIVE AND ACTIVE OPTICAL COMPONENTS (10 Hours)

Principle And Operation Of Optical Source, Detectors, Couplers, Isolators, Circulators, Modulators, Multiplexers, Filters, Switches, Amplifiers.

WDM SYSTEM DESIGN (10 Hours)

WDM System Classification, Applications and Advantages, WDM System Model, System Requirements, Optical System Design Considerations, Power Budget, Bandwidth Budget, OSNR Based DWDM System Design, System Performance Measurement Parameters, Power Penalty In System.

DISPERSION MANAGEMENT (04 Hours)

Need of Dispersion Management, Pre-Compensation, Post Compensation, Dispersion Compensation Techniques

OPTICAL SYSTEMS (05 Hours)

Direct Intensity Modulation (D-IM), Subcarrier Intensity Modulation, Coherent and Phase-modulated Systems.

NONLINEARITIES (06 Hours)

Distortion In Signal Due To Nonlinearities In Fibers, Self-Phase Modulation, Cross Phase Modulation, Stimulated Raman Scattering, Stimulated Brillouin Scattering, Four Wave Mixing, Optical Solitons.

RECENT ADVANCEMENTS IN OPTICAL COMMUNICATION (04 Hours)

Visible Light Communication, Wireless Optical Communication, LiFi, Free Space Optics, Passive Optical Networks, Free Space Optics.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Senior J. M., "Optical Fiber Communication - Principle And Practice", PHI, 3rd Ed., 2018
2. Gerd Kaiser, "Optical Fiber Communication", McGraw Hill, 5th Ed., 2017.
3. T. L. Singhal, "Optical Fiber Communications: Principles and Applications", Cambrige, 1st Ed., 2017.
4. Agrawal G.P., "Fiber Optic Communication Systems", John Wiley & Sons, 4th Ed., 2015.
5. Ramaswami Rajiv and Sivarajan K. N., "Optical Networks: A Practical Perspective", Elsevier, Morgan Kaufmann Publishers, 3rd Ed., 2012.
6. Gp Capt KS Mathur (Retd.), "Fiber Optics Fundamentals and Advances in Optical Communications", Bluerose Publishers Pvt. Ltd., 1st Ed., 2021.

M.Tech. I (Communication systems) Semester – I

Advance DSP

L	T	P	Credit
3	0	0	03

ECCS105 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe different type of signals and systems, and analyze different system characteristics therein
CO2	Understand the concept of FIR, IIR, linear prediction filter, power spectrum estimation
CO3	Solve the problem related to different filtering techniques and power spectrum estimation
CO4	Compare and Analyze different filtering techniques
CO5	Design different filtering techniques for different signal processing applications

2. Syllabus:

REVIEW OF DISCRETE SIGNAL REPRESENTATION AND ANALYSIS (06 Hours)

Continuous and discrete time signals, noise signal, different type of signals, operations of signals: addition, subtraction, multiplication, scaling, magnification, decimation, interpolation, differentiation and integration, static and dynamic system, LTI system, DFT and FFT

TIME AND FREQUENCY-DOMAIN DESIGN TECHNIQUES FOR IIR AND FIR FILTERS (09 Hours)

FIR And IIR Filter Specifications, FIR Filter Design- Fourier series method and Frequency Sampling Method, Design Of IIR Digital Filters: Butterworth, Chebyshev And Elliptic Approximations, Low Pass, Band Pass, Band Stop And High Pass Filters, Bilinear Transformation Method

EFFECT OF FINITE REGISTERS LENGTH (04 Hours)

Number Representation, Quantization Error, Round-Off Error, Overflow Error, Limit Cycle, System Noise behaviour, Noise Filtering By LSI System, Noise in a Cascade Of 2nd Order Filter, Stability of Linear Filter

MULTIRATE SIGNAL PROCESSING (05 Hours)

General Rate-Changing System, Integer-Factor Interpolation and Decimation and Rational-Factor Rate Changing, Efficient Multirate Filter Structures, Over sampling D/As, Perfect-Reconstruction Filter Banks and Quadrature Mirror Filters.

OPTIMAL FILTERING OF RANDOM SIGNALS (08 Hours)

Innovations Representation of a Stationary Random Process, Prediction, linear prediction: forward and backward methods, Linear prediction based filter analysis, Prediction error, Levinson recursion method for solving Toeplitz system of equations, AR and ARMA Filter, MLE and MAP, LMS and RLS adaptive filters.

POWER SPECTRUM ESTIMATION/ANALYSIS (06 Hours)

Non-parametric method, Parametric method, periodogram, Eigen analysis for spectral Estimation.

APPLICATION OF DSP **(07 Hours)**

Speech signal processing: Time domain processing of speech, methods for extracting the parameters, Filter bank analysis of speech, radar signal processing, musical sound processing, recent applications.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Salivahanan S, “Digital Signal Processing”, Fourth Edition, Tata McGraw-Hill, 2019.

2. Rabiner L. R. and Gold B., “Theory and Applications Of Digital Signal Processing”, First Edition, Prentice Hall, 1992.

3. Oppenheim A. V. and Schafer, “Discrete Time Signal Processing”, Pearson, Third edition, 2014.

4. Proakis John G. and Manolakis D.G., “Digital Signal Processing: Principle, Algorithms and Applications”, Fourth Edition, Pearson, 2006.

5. Kay, Steven M “Fundamentals of statistical signal processing”, Prentice Hall, 1998.

6. L. R. Rabiner and R. W. Schafer, Digital Processing of Speech Signals, Pearson Education India, First Edition, 2003.

Other Reference Books:

1. Mitra Sanjit K.,“Digital Signal Processing - A computer Based Approach”, McGraw-Hill,2007

M.Tech. I (Communication systems) Semester – I

Communication Lab – I

L	T	P	Credit
0	0	6	03

ECCS107 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Understand the basic concepts and advancements in RF Circuits, DSP and fiber optic communication systems.
CO2	Demonstrate the device characteristics linearity in various signal and systems analog and digital modulation schemes in fiber optics
CO3	Interpret the RF Circuits and waveguides, MultiMate signal processing model and fiber optic communication system models by using the simulation software.
CO4	Design and analyse the operating principle of RF Circuits and systems, wavelets and single channel fiber optic communication systems
CO5	Design and analyse the operating principle of RF Circuits and systems, Multirate filters for 2D signal processing in WDM solutions systems and the effect of nonlinearity in optical fiber

2. List of Experiments:

RF Circuits & Systems

01) Study of Microwave Bench.
02) Plot of Standing Wave Pattern and Finding VSWR for Different Loads.
03) Characteristics of Waveguide Directional Coupler.
04) Solving Problems Using Z – Match Software for Smith Chart.
05) Measurement of Insertion Loss and VSWR of Bandstop Filter Using Simulated Network Analyzer.
06) Measurement of Transmission Loss and Reflection Loss for 50 Ohms Microstrip Line.
07) Determination of Resonance Frequency of Microstrip Ring Resonator and Calculation of Relative Dielectric Constant of Substrate.
08) Measurement of Power Division, Isolation and Return Loss of A 3 dB Power Divider.
09) Measurement of Coupling and Isolation Loss of a Backward Wave Microstrip Direction Coupler.
10) Measurement of Gain of Microstrip LNA Amplifier.
11) Study of Microwave Communication Link.

Advance Digital Signal Processing

01) Write a MATLAB Program to Get Fourth Order Butterworth Filter.
02) Write a MATLAB Program for Interpolation and Decimation.
03) Write a MATLAB Program to Decimate by Factor of Eight in Two Stages.
04) Write a MATLAB Program for Power Spectral Density of Signal with Random Noise and Draw Spectrum of Chirped Signal.

05) Write A MATLAB Program to Plot the Zeros and Poles of System and Comment on Stability.

06) Write A MATLAB Program to Pass Various Sinusoids of Freq. 50 Hz, 200 Hz and 300 Hz Through Band Pass Filter Having Cutoff Freq. Wn = [0.125, 0.275]; Generated Through Kaiser Window. Draw Its Freq. Spectrum and Output in Time Domain.

07) Write A MATLAB Program for Generation of Moving Average Filter Which Is Basic Low Pass Filter.

08) Write A MATLAB Program for Haar Wavelet Signal Decomposition and Reconstruction.

09) Write A MATLAB Program for DFT Filter Bank Realization.

10) Mini Projects.

Advance Optical Communication

01) Setting-Up A Fiber Optic Analog Link Using OFT Kit.

02) Setting-Up A Fiber Optic Digital Link Using OFT Kit.

03) Finding The Losses and NA for Given Optical Fiber Using OFT Kit.

04) Study of The Splicing Kit, Light Source and Power Meter.

05) Dispersion Comparison Using FOTX-RX Using FOT Kit.

06) TDM Frame Generation and Transmission-Reception Using FOT Kit.

07) Performance Analysis of Single Channel Fiber Optic Communication Link Using Optisystem 17.0.

08) Performance Analysis of Fiber Optic Communication Link with FEC Coder and Decoder Using Optisystem 17.0.

09) Performance Analysis Of Multichannel WDM Link Using Optisystem 17.0..

10) Performance Analysis Of Bidirectional DWDM Link Using Optisystem 17.0..

11) Performance Analysis Of Analog And CATV Transmission Using Optisystem 17.0..

12) Mini Project

(Total Contact Time: 90 Hours)

M.Tech. I (Communication systems) Semester – I

Seminar

L	T	P	Credit
0	0	4	02

ECCS109 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Identify the plan of action from the real-world technical aspects to develop a thought process and basic understanding and extract a detailed literature survey
CO2	Comprehend the detailed design for proof-of-concept, related data, and results to come to some concluding remarks.
CO3	Write the report with well-organised motivational aspects, technical aspects, and comprehension with proficiency in English.
CO4	Develop the effective and innovative presentation using modern tools/software.
CO5	Deliver the oral presentation with the soft skills of listening, debating, answering etc.

ELECTIVE COURSES I & II: SEMESTER - I

M.Tech. I (Communication systems) Semester – I

Information Theory and Coding

L	T	P	Credit
3	0	0	03

ECCS111 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Understand the notion of information in a mathematically sound way.
CO2	Illustrate entropy, joint entropy, relative entropy, conditional entropy, and channel capacity of a system.
CO3	Analyze lossless data compression techniques with varying efficiencies as per problem requirements.
CO4	Evaluate decoding strategies for block codes, linear codes, cyclic codes and BCH codes for detection and correction of errors.
CO5	Design convolutional Encoding and Decoding that meets design objectives like required protection for detection and correction of errors.

2. Syllabus:

INFORMATION THEORY **(06 Hours)**

Introduction to Information Theory, Entropy, Properties of Entropy, Measures for Continuous, Random Variable, Relative Entropy, Conditional and Joint Entropy, Measure of Information, Average Information, Extension of Zero Memory Source.

SOURCE CODING **(12 Hours)**

Properties of Codes, Variable Length Codes, Uniquely Decodable Codes, Kraft's Inequality, Prefix Codes, Average Length of a Code, Shannon's First Theorem, Shannon's Encoding Algorithm, Shanon-Fano Codes, Huffman's Codes, Arithmetic Codes, Lempel Ziv, Run Length Code, Code Efficiency and Redundancy, Practical Application of Source Coding: JPEG Compression.

CHANNEL MODELS AND CHANNEL CAPACITY **(08 Hours)**

Discrete Communication Channels, Continuous Channels, Entropy Functions and Equivocation, Mutual Information, Channel Capacity, redundancy and efficiency of channels, Symmetric channels, Binary Symmetric Channel, Binary Erasure Channel, Noise-Free Channel, Cascaded channels, Binary asymmetric channel, Shannon theorem

BLOCK CODES AND LINEAR CODES **(06 Hours)**

Introduction to Galois Field, Single Parity Check Codes, Product Codes, Hamming Codes, Minimum Distance of Block Codes, Linear Block Codes, Generator Matrices, Parity Check Matrices, Encoder, Standard array and Syndrome decoding, Error Correction and Error Detection Capabilities.

CYCLIC and BCH CODES **(08 Hours)**

Introduction to Cyclic Codes, Generator Polynomial, Syndrome Polynomial and Matrix Representation, Fire Code, Golay Code, CRC Codes and Circuit Implementation of Cyclic Codes, Introduction to BCH Codes: Generator Polynomials, Multiple Error Correcting BCH Codes, Decoding of BCH Codes, Introduction to Reed Solomon (RS) Codes.

CONVOLUTION CODE **(05 Hours)**

Introduction to Convolutional Codes, Trellis Codes: Generator Polynomial Matrix and Encoding using Trellis, Vitrebi Decoding, Introduction to Turbo Codes, Introduction to Trellis Coded Modulation (TCM), Introduction to Space Time Block Codes (STBC).

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Ranjan Bose, “Information theory, coding and cryptography”, Tata McGraw-Hill,3rd Edition, 2016

2. T. M. Cover and J. A. Thomas, “Elements of Information Theory“, 2nd Ed., John Wiley & Sons, New Jersey, USA, 2006.

3. Salvatore Gravano,“Introduction to Error Control Codes”, Oxford University Press,1st Edition,2007

4. Shu Lin and Daniel Costello, “Error Control Coding”, 2nd Ed., by Pearson, 2004.

5. Todd K. Moon, “Error Correcting Coding”, Wiley India Edition,2006

M.Tech. I (Communication systems) Semester – I

Digital Satellite Communication

L	T	P	Credit
3	0	0	03

ECCS113 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe terminology relating to Satellite system communication, orbital mechanism, orbital effects on communication etc.
CO2	Apply satellite communication techniques incorporating advanced satellite multiple accesses schemes, modulation and coding schemes.
CO3	Analyse satellite link budget, C/I calculations
CO4	Classify the state-of-the-art access schemes, coding schemes, functionality of satellite systems,
CO5	Design problem based on, satellite networking, Navigation and satellite personal communications.

2. Syllabus:

COMMUNICATION SATELLITE : ORBIT AND DESCRIPTION (05 Hours)

Orbit Period & Velocity, Effects Of Orbital Inclination, Azimuth & Elevation, Coverage Angle & Slant Range, Eclipse, Placement Of A Satellite In A Geostationary Orbit, Satellite Description.

EARTH STATION (06 Hours)

Earth Station Antenna, High Power Amplifier, Low Noise Amplifier, Upconvertrer, Down Converter, Monitoring & Control, Reliability.

SATELLITE LINK (06 Hours)

Basic Link Analysis, Interference Analysis, Rain-Induced Attenuation, Rain-Induced Cross Polarization Interference, System Availability, Satellite Links Design, Satellite-Satellite Link Using Lasers.

FREQUENCY DIVISION MULTIPLE ACCESS (04 Hours)

FDM-FM-FDMA, SCPC, FM-FDMA TV, Companded FDM-FM-FDMA And SSB-AM-FDMA, Intermodulation Products, Resulting From Amplitude Nonlinearity And from both Amplitude & Phase Nonlinearities, Optimized C / I Plus Noise Ratio.

TIME DIVISION MULTIPLE ACCESS (08 Hours)

TDMA Frame Structure, TDMA Burst Structure, TDMA Frame Efficiency, TDMA Super frame Structure, Frame Acquisition & Synchronization, Satellite Position Determination, Burst Time Plan, Control & Coordination By The Reference Station, TDMA Timing, TDMA Equipment, Advanced TDMA Satellite Systems.

EFFICIENT TECHNIQUES: DEMAND ASSIGNMENT MULTIPLE ACCESS & DIGITAL SPEECH INTERPOLATION (05 Hours)

The Erlang B Formula, Types Of Demand Assignments, DAMA Characteristics, Real –Time Frame Reconfiguration, DAMA Interfaces, SCPC–DAMA, SPADE, Digital Speech Interpolation.

SATELLITE SPREAD SPECTRUM COMMUNICATIONS (05 Hours)

Direct Sequence Spread Spectrum System, Direct Sequence Code Division Multiple Access, Frequency Hop Spread Spectrum Systems, Frequency Hop Code Division Multiple Access, DS Acquisition & Synchronization, FH Acquisition & Synchronization, Satellite On-Board Processing.

MOBILE SATELLITE NETWORKS (03 Hours)

Operating Environment, MSAT Network Concept, CDMA MSAT Network, Statistics of Mobile Propagation.

SATELLITE APPLICATION AND CHALLENGES (03 Hours)

VSAT, Radarsat, GPS, Navigation, Interferences

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Pratt T. and Bostian C. W., “Satellite Communications” John Wiley & Sons, 2nd Ed., 2003.
2. HaTri. T., “Digital Satellite Communications”, McGraw-Hill, 2nd Ed., Reprint 2017
3. Roddy Dennis, “Satellite Communications”, McGraw-Hill, 4th Ed., 2006,
4. Tomasi Wayne, “Advanced Electronic Communication Systems”, PHI, 6th Ed., 2014
5. Nagaraja N.S., “Elements Of Electronic Navigation”, TMH, 2nd Ed., 2000.

M.Tech. I (Communication systems) Semester – I

Cognitive Radio

L	T	P	Credit
3	0	0	03

ECCS115 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Explain the fundamentals of SDR and CR with basic differences.
CO2	Compare the optimum spectrum sensing techniques
CO3	Analyse the sensing accuracy versus sensing overhead for given conditions.
CO4	Evaluate the performance of spectrum sensing and spectrum management techniques over cognitive radio
CO5	Design and analysis of performance parameters over CR architecture for the given techniques and parameters

2. Syllabus:

SOFTWARE DEFINED RADIO (SDR) **(09 Hours)**

Essential functions of the SDR, SDR architecture, design principles of SDR, traditional radio implemented in hardware and SDR, transmitter architecture and its issues, A/D & D/A conversion, parameters of practical data converters, techniques to improve data converter performance, complex ADC and DAC architectures, digital radio processing, reconfigurable wireless communication systems.

COGNITIVE RADIO (CR) FEATURES AND CAPABILITIES **(10 Hours)**

CR functions, CR architecture, components of CR, CR cycle, CR and dynamic spectrum access, interference temperature, CR architecture for next generation networks, CR standardization, Concept of primary and secondary users, Licensed and unlicensed spectrums in CR.

SPECTRUM SENSING AND IDENTIFICATION **(09 Hours)**

Primary signal detection, energy detector, cyclostationary feature detector, matched filter, cooperative sensing, spectrum opportunity, spectrum opportunity detection, fundamental trade-offs: performance versus constraint, sensing accuracy versus sensing overhead.

SPECTRUM MANAGEMENT OF COGNITIVE RADIO NETWORKS **(08 Hours)**

Spectrum decision, spectrum sharing and spectrum mobility, mobility management of heterogeneous wireless networks, research challenges in CR Spectrum switching

COGNITIVE RADIO NETWORKS (CRN) ARCHITECTURE **(09 Hours)**

Terminal architecture of CRN, diversity radio access networks, routing in CRN, Control of CRN, Self-organization in mobile communication networks, security in CRN, cooperative communications, cooperative wireless networks, user cooperation and cognitive systems.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Kwang-Cheng Chen and Ramjee Prasad, “Cognitive Radio Networks”, John Wiley & Sons, Ltd, 2009.
2. Alexander M. Wyglinski, Maziar Nekovee, and Y. Thomas Hou, “Cognitive Radio Communications and Networks - Principles and Practice”, Elsevier Inc., 2010.
3. Bruce Fette, “Cognitive radio technology”, Elsevier, 2nd edition, 2009.
4. Jeffrey H. Reed “Software Radio: A Modern Approach to radio Engineering”, Pearson Education Asia, 2006.
5. Linda Doyle, “Essentials of Cognitive Radio”, Cambridge University Press, 2009.

M.Tech. I (Communication systems) Semester – I

Probability and Random Processes

L	T	P	Credit
3	0	0	03

ECCS117 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Explain Sample space and events Combinatorics, Joint and conditional probabilities
CO2	Compare CDF, PDF and established a relation between PDF and CDF.
CO3	Classify Stationary, Nonstationary, Strict-Sense and Wide-Sense Stationary Processes
CO4	Analyze Autocovariance, Power Spectral Density, Joint Statistical Averages of Two Random Processes, Crosscorrelation And Crosscovariance, Ergodicity etc.
CO5	Evaluate response of linear systems through random signals though various output parameters.

2. Syllabus:

INTRODUCTION TO PROBABILITY THEORY **(05 Hours)**

Sets, fields, sample space and events, axiomatic definition of probability. Combinatorics, Joint and conditional probabilities, Independence, total probability, Bayes' rule

RANDOM VARIABLES **(12 Hours)**

Cumulative Distribution Function, Probability Density Function. Relation Between Probability And Probability Density, Joint Cumulative Distribution And Probability Density, Characteristic functions and moment generating functions, Average Value And Variance Of A Random Variable, Gaussian Probability Density, Error Function, Rayleigh Probability Density,Mean And Variance Of The Sum Of Random Variables, Correlation Between Random Variables, Central Limit Theorem, liner minimum mean square error and orthogonality principle, Chebysev inequality Sequences Of Random Variables, Convergence Of Sequences Of Random Variables. Weak law of large number.

STOCHASTIC PROCESSES **(10 Hours)**

Stationary, Nonstationary, Strict-Sense and Wide-Sense Stationary Processes, Gaussian Processes, Poisson Process and the Markov Process.

EXPECTED VALUES OF A RANDOM PROCESS **(10 Hours)**

The Mean Value, Autocorrelation, Autocovariance, Power Spectral Density, Joint Statistical Averages of Two Random Processes, Cross-correlation And Cross-covariance, Ergodicity, Mean Square Continuity, Mean Square Derivative And Mean Square Integral Of Stochastic Processes, Ergodic Processes. White noise process and white noise sequence.

RANDOM PROCESS THROUGH LINEAR SYSTEMS **(08 Hours)**

Response of Linear Systems to Random Signals, Stationarity of the Output, Autocorrelation and Power Spectral Density of the Output, Examples with White Noise as the Input, Interpretation of the PSD, Bandlimited Random Processes, Weiner Filtering, Optimum Linear Systems, The Kalman Filter.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Papoulis,"Probability, Random Variables And Stochastic Processes", McGraw-Hill,4th Ed, 2017.
2. Alberto Leon-Garcia, Probability, Statistics, and Random Processes for Electrical Engineering, Pearson, 3rd Ed, 2008.
3. Sheldon M. Ross Introduction to Probability Models Academic Press, 2014.
4. Steven Kay, Intuitive Probability and Random Processes using MATLAB, 2006.
5. Vijay K. Rohatgi, A.K. Md. Ehsanes Salehi, An Introduction to Probability and Statistics, Wiley, 2011.
6. Hayes Monson H.,"Statistical Digital Signal Processing", John Wiley,1st Ed.,1996.

M.Tech. I (Communication systems) Semester – I

Antenna Theory And Design

L	T	P	Credit
3	0	0	03

ECCS119 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe the working principle of different antennas.
CO2	Apply the developed theories to model different radiating systems.
CO3	Compare the various antennas in terms of their design, functionality, use etc.
CO4	Evaluate the radiation and impedance characteristics of aperture, broadband, microstrip antennas and arrays.
CO5	Design suitable antennas and validate their performance for antenna arrays and smart antennas, mathematically analyze the types of antenna arrays.

2. Syllabus:

FUNDAMENTAL PARAMETERS OF ANTENNAS **(06 Hours)**

Radiation Pattern, Radiation Power Density, Radiation Intensity, Beamwidth, Directivity, Antenna Efficiency, Gain, Beam Efficiency, Bandwidth, Polarization, Input Impedance, Antenna Radiation Efficiency, Antenna Vector Effective Length and Equivalent Areas, Maximum Directivity and Maximum Effective Area, Friis Transmission Equation and Radar Range Equation.

RADIATION INTEGRALS AND POTENTIAL FUNCTIONS **(07 Hours)**

Vector Potential A for an Electric Current Source J, Vector Potential F for a Magnetic current Source M, Electric and Magnetic Fields for Electric (J) and Magnetic (M) Current Sources, Solution of the inhomogeneous Vector Potential Wave Equation, Far-field Radiation, Duality Theorem, Reciprocity and Reaction Theorems

LINEAR WIRE AND LOOP ANTENNA **(06 Hours)**

Infinitesimal dipole, Finite-length Dipole, Linear Elements near Conductors, Dipoles for Mobile Communication, Small Circular Loop, Circular Loop of Constant Current Folded Dipole.

APERTURE AND HORN ANTENNAS **(06 Hours)**

Huygens' Principle, Radiation from Rectangular and Circular Apertures, Design Considerations, Babinet's Principle, Radiation from Sectoral and Pyramidal Horns, Design Concepts.

REFLECTOR ANTENNAS **(05 Hours)**

Parabolic Reflector, Paraboloidal Reflector, Aperture Pattern of Large Circular Apertures with Uniform Illumination, Off axis operation of Paraboloidal Reflectors, Cassegrain feed system.

BROADBAND ANTENNAS AND MATCHING TECHNIQUES **(05 Hours)**

Broadband concept, Log-periodic antennas, Frequency independent antennas. Matching Techniques, Travelling Wave Antennas

MICROSTRIP ANTENNAS **(04 Hours)**

Basic characteristics of microstrip antennas, Feeding methods, Methods of Analysis, Design of Rectangular and Circular Patch Antennas.

ANTENNA ARRAYS ANALYSIS AND SYNTHESIS **(06 Hours)**

Two-Element Array, N-Element Linear Array: Uniform Amplitude and Spacing, N-Element Linear Array: Uniform Spacing, Nonuniform Amplitude, Planar Array, Circular Array, Continuous Sources, Schelkunoff Polynomial Method, Fourier Transform Method.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. C. A. Balanis, “Antenna Theory and Design”, 4th Ed., John Wiley & Sons., 2016.
2. J.D. Krauss, “Antennas for all Applications”, 3rd Ed., Tata McGraw-Hill, 2008.
3. W. L. Stutzman, and G. A. Thiele, “Antenna Theory and Design”, 2nd Ed., John Wiley & Sons, 1998.
4. R. S. Elliot, “Antenna Theory and Design”, Revised edition, Wiley-IEEE Press., 2003.
5. Harish A. R. and Sachindananda M., "Antennas and Wave Propagation", Oxford University Press, 1st Ed., 2007.

M.Tech. I (Communication systems) Semester – I

Machine Learning and Its Applications

L	T	P	Credit
3	0	0	03

ECCS121 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Understand fundamentals of Machine Learning and classify machine learning algorithms into supervised and unsupervised.
CO2	Solve problems using various machine learning techniques.
CO3	Analyze a given problem and determine which algorithm to use.
CO4	Evaluate performance of different ML algorithms and select suitable algorithm for a given problem.
CO5	Design applications using various ML algorithms to solve real life problems.

2. Syllabus:

INTRODUCTION TO MACHINE LEARNING AND PREREQUISITES (11 Hours)

Definition and history of machine learning, Types of Machine Learning: Supervised, Unsupervised, and Reinforcement Learning, Applications of Machine Learning, Essential mathematics for machine learning: linear algebra and probability theory, Bayesian learning, Naïve Bayes, Normal density and discriminant function.

SUPERVISED MACHINE LEARNING ALGORITHMS (13 Hours)

Regression: Linear regression, Multiple linear regression, Polynomial regression, Ridge regression, Lasso Regression. Classification: Perceptron criteria, Logistic Regression, Multi-class logistic regression (one-vs-all), K-nearest neighbours (KNN), Linear support vector machine (SVM), Kernel SVM, Linear Machine with hinge loss, Decision trees and random forests.

UNSUPERVISED MACHINE LEARNING ALGORITHMS (12 Hours)

Clustering: K-Means clustering, Fuzzy K-means clustering, Mean shift clustering, Hierarchical clustering, DBSCAN, Gaussian mixture model, Expectation Maximization Algorithm. Dimensionality Reduction: Dimensionality Problem, Principal component analysis (PCA), t-Distributed Stochastic Neighbour Embedding (t-SNE), Linear Discriminant Analysis (LDA). Anomaly Detection.

INTRODUCTION TO DEEP LEARNING (09 Hours)

Neural Networks: Biological Neurons vs. Artificial Neurons, Perceptron, Learning XOR, Multilayer perceptron (MLP), Feed forward neural networks, Activation Functions: Sigmoid, Tanh, ReLU, etc. Training Neural Networks: Forward and backward propagation, Gradient Descent, Optimization algorithms, Loss functions, Overfitting and Regularization (Dropout, Batch Normalization). CONVOLUTIONAL NEURAL NETWORKS: Convolution, Cross correlation, building blocks of CNN, MLP vs CNN, Popular CNN models, Vanishing and Exploding Gradient.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. C. M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2nd Ed., 2011.
2. Kevin P. Murphy, Machine Learning: A Probabilistic Perspective, The MIT Press, 2012.
3. Ethem Alpaydin, Introduction to Machine Learning, The MIT Press, 4th Ed, 2020.
4. Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar, Foundations of Machine Learning, The MIT Press, 2nd Ed, 2018.
5. Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press, 2016.

M.Tech. I (Communication systems) Semester – I

Digital VLSI Design

L	T	P	Credit
3	0	0	03

ECVL101 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Understand VLSI design flow and CMOS inverter
CO2	Implement CMOS combinational and Sequential logic
CO3	Analyze circuit characteristic
CO4	Evaluate circuit performance
CO5	Design digital subsystems

2. Syllabus:

INTRODUCTION TO VLSI DESIGN (04 Hours)

Historical Perspective, Design Hierarchy, Concepts Of Regularity, Modularity And Locality, VLSI Design Challenges, Introduction of VLSI Design Flow:, From Custom to Semi Custom and Structured Array Design Approaches, Custom Circuit Design, Cell-Based Design Methodology: Standard Cell, Compiled Cells, Macrocells, Megacells and Intellectual Property, Semi-Custom Design Flow; Array-Based Implementation Approaches: Pre-Diffused (or Mask-Programmable) Arrays, Pre-Wired Arrays.

CMOS INVERTER BASICS and COMBINATIONAL LOGIC CIRCUIT (09 Hours)

Brief introduction to MOS transistor models and SPICE parameters; process parameters and design rules. Introduction, The Static CMOS Inverter — An Intuitive Perspective, Evaluating the Robustness of the CMOS Inverter (The Static Behavior): Switching Threshold, Noise Margins, Robustness Revisited; Performance of CMOS Inverter (The Dynamic Behavior): Computing the Capacitances, Propagation; Delay: First-Order Analysis, Propagation Delay from a Design Perspective; Power, Energy and Energy- Delay: Dynamic Power Consumption, Static Consumption, Perspective: Technology Scaling and its Impact on the Inverter Metrics. CMOS Combinational Logic Circuits, Complex Logic Circuits, Layout Techniques, Behavior Of MOS Logic Elements, CMOS Pass Gate and Transmission Gate, Design of combinational circuit using pseudo-nMOS and DCVSL and DSL logic gates. CPL, DPTL and swing restored pass transistor logic styles

SEQUENTIAL LOGIC CIRCUIT (08 Hours)

Timing Metrics for Sequential Circuits, Classification of Memory Elements; Static Latches and Registers: The Bistability Principle, Multiplexer-Based Latches, Master-Slave Edge-Triggered Register, Low-Voltage Static Latches, Static SR Flip-Flops—Writing Data by Pure Force; Dynamic Latches and Registers: Dynamic Transmission-Gate Edge-triggered Registers, C2MOS—A Clock-Skew Insensitive Approach, True Single-Phase Clocked Register (TSPCR); Alternative Register Styles: Pulse Registers, Sense-Amplifier Based Registers; Pipelining (An approach to optimize sequential circuits): Latch- vs. Register-Based Pipelines, NORA-CMOS—A Logic Style for Pipelined Structures; Non-Bistable Sequential Circuits: The Schmitt Trigger, Monostable Sequential Circuits, Astable Circuits; Perspective: Choosing a Clocking Strategy,

DYNAMIC LOGIC CIRCUIT (05 Hours)

Dynamic Logic (Basic Principles), Speed and Power Dissipation of Dynamic Logic, logic styles including np, Domino, NORA and TSPC logic, Issues in Dynamic logic due to charge sharing and race conditions, Cascading Dynamic Gates; Perspectives: How to Choose a Logic Style

CIRCUIT CHARACTERIZATION, PERFORMANCE ESTIMATION AND TESTING (6 Hours)

Interconnect, Estimation of Interconnect Parasitic, Delay Estimation, Logical Efforts And Transistor Sizing, Power Dissipation, Design Margin, Reliability, Testing: Introduction, Automatic Test pattern Generation (ATPG), Design for Test (DFT), Buit-in self Test (BIST)

DIGITAL SUBSYSTEM DESIGN (13 Hours)

Design of IO buffers and on chip load drivers; PLL, clock generation and clock buffering; design of memory cells and sense amplifiers. Design of adders - Ripple carry, Manchester carry, carry look ahead, carry select and carry save. Design of multipliers (for unsigned and signed) - sequential, parallel, carry save, Booth multipliers; Wallace tree structures. Design of shifters and floating point arithmetic units

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Rabaey Jan M., Chandrakasan Anantha and Borivoje Nikolic, "Digital Integrated Circuits (Design Perspective)", 2nd Ed., Prentice Hall of India, 2016 (Reprint).
2. Kang and Leblebici,“CMOS Digital Integrated Circuits: Analysis and Design”, Tata McGraw-Hill, 4th Edition, 2019
3. Baker R. Jacob, Li H. W. & Boyce D. E.,“CMOS Circuit Design, Layout And Simulation”, Wiley, 4th Edition, 2009.
4. Weste and Harris,“CMOS VLSI Design: A Circuits and Systems Perspective”, Pearson Education, 4th Edition, 2020.
5. Pucknell and Eshraghian: “Basic VLSI Design”, Prentice Hall of India, 3rd Edition, 2003

M.Tech. I (Communication systems) Semester – I

Embedded Systems

L	T	P	Credit
3	0	0	03

ECVL105 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Understand Embedded systems and describe CPU architectures and variety of microcontrollers.
CO2	Describe CPU processor, its modes, exception handling, instruction pipelining and basic programming.
CO3	Implementation with Assembly and C language programming for ARM Cortex-M.
CO4	Analyze 32-bit ARM microcontroller architecture, External Memory, Counters & Timers, Serial Data Input/Output and Interrupts. Design for interfacing Keys, LED/LCD Displays, ADC And DAC.
CO5	Design a typical cost-effective real-world embedded system with appropriate hardware/software components and embedded OS.

2. Syllabus:

INTRODUCTION TO EMBEDDED SYSTEMS (08 Hours)

Overview and Characteristics of Embedded Systems, Classification and Application Areas, Process of Embedded System Development, RISC Vs CISC CPU Architectures, 8/16/32 bit Microcontrollers Family, Components in embedded system development environment (IDE)

ARM CORTEX M3/M4 ARCHITECTURE (10 Hours)

Overview of ARM Cortex family, Operation modes and states, Registers, Special Registers, Floating point Registers, Memory system and MPU, Exception and interrupts, System control block, OS Support features, ARM Instruction Set Architecture, Arithmetic and Logic, Load and Store, Branch and Conditional Execution.

PROGRAMMING CORTEX M3/M4 IN ASSEMBLY and C (10 Hours)

Structured Programming, Subroutines, 64-bit Data Processing, Mixing C and Assembly, Interrupt and NVIC, Fixed-point and Floating-point Arithmetic, Writing optimized ARM assembly/C code, Exception and fault handling routines.

USING EMBEDDED OS (08 Hours)

Introduction to Embedded OS, Task and Threads, Creation of Threads, Inter-thread communications, Signal event, Semaphores, Message queue, OS based programming examples.

CIRCUIT CHARACTERIZATION, PERFORMANCE ESTIMATION AND TESTING (09 Hours)

General-purpose I/O, General-purpose Timers, Real-time Clock (RTC), Direct Memory Access (DMA), Analog-to-Digital Converter (ADC), Digital-to-Analog Converter (DAC), Serial Communication interface such as UART, I2C, SPI, Ethernet, CAN etc.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Joseph Yiu, "A definitive guide to the ARM-Cortex M3 and Cortex-M4 Processors", 3rd Ed., Newnes, 2013
2. A.N.Sloss, D.Symes and C. Wright, "ARM System Developer's Guide: Designing and Optimizing System Software", Elsevier, 2004
3. Y. Zhu, "Embedded Systems with Arm Cortex-M3 Microcontrollers in Assembly Language and C", E-Man Press LLC, 2014
4. Wayne Wolf, "Computers as Components: Principles of Embedded Computing System Design (The Morgan Kaufmann Series in Computer Architecture and Design)", 2nd Edition, 2008
5. Prasad K. V. K. K., "Embedded / Real-Time Systems: Concepts, Design And Programming", DreamTech Press, 2005

M.Tech. I (Communication systems) Semester – I

Semiconductor IC Technology

L	T	P	Credit
3	0	0	03

ECVL111 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe and analyze material processing techniques and Pattern Transfer process
CO2	Explain, and compare the concept behind thin film deposition, and characterization techniques.
CO3	Describe and compare metal contact formation, interconnect, bonding and packaging.
CO4	Demonstrates different fabrication, characterization, and metallization techniques.
CO5	Design basic semiconductor devices and their characterization.

2. Syllabus:

INTRODUCTION TO MICROELECTRONIC FABRICATION AND MATERIALS (08 Hours)

Semiconductor substrate: Crystal structure, Crystal defects, Crystal growth, Wafer fabrication and basic properties of Silicon Wafers, Wafer cleaning, and native oxide removal, Substrates beyond Silicon, Surface reactions, Dopants, Defects in epitaxial growth, Clean Room, and Safety requirements. Diffusion, Thermal Oxidation, Ion implantation, Etching.

MASK FABRICATION AND ADVANCED LITHOGRAPHY TECHNIQUES (05 Hours)

Overview, Optical lithography, Photoresist, Mask Development, Patterning Strategies, Electron beam lithography process, EUV Lithography, X-ray lithography, and Other advanced lithography systems

THIN-FILM TECHNOLOGIES (09 Hours)

Physical Vapor Deposition: Evaporation Systems, Sputtering systems, and state-of-art Systems. Chemical Vapor Deposition: CVD system, Advanced CVD systems: LPCVD, UHCVD, AACVD, and advanced systems.

Epitaxial Deposition: MOCVD, MBE, and CBE.

Solution-Based Deposition Techniques: Electrodeposition, Spin Casting, Printing, Layer-by-Layer Deposition, Colloidal Synthesis.

MEMS FABRICATION TECHNIQUES (05 Hours)

Silicon Pressure Sensors, Micro-Electro-Mechanical Systems, Micromachining Techniques, Isotropic Etching and Anisotropic Etching, Wafer Bonding, and LIGA Processes.

NANOSCALE DEVICE CHARACTERIZATION TECHNIQUES (09 Hours)

X-ray diffraction, X-ray photoelectron Spectroscopy, Spectroscopic Ellipsometry, Field Emission Scanning Electron Microscope, Transmission Electron Microscope, Atomic Force Microscope, Raman Spectroscopy, UV-Vis Measurement, Photo-Luminescence, Hall Measurement, Capacitance Voltage Measurement and Current-voltage measurement.

PROCESS INTEGRATION **(04 Hours)**

Contacts and metallization: Junction and oxide isolation, Si on insulator, Schottky and Ohmic contacts, Multilevel metallization. CMOS technologies: Device behavior, Basic 3 μm technologies, Device scaling. Circuit Manufacturing: Yield, Particle control, Design of experiments, computer-integrated manufacturing.

INTERCONNECTS, BONDING, AND PACKAGING: **(05 Hours)**

Metallization, Silicides, CVD Tungsten Plug Process, Gold Wire Bonding and Other Bonding Technologies, Package Types, Assembly Techniques, Package Fabrication Technology, Package Design Considerations.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Stephen A. Campbell, "The Science and Engineering of Microelectronic Fabrication", 2nd edition Oxford University Press, 2006.
2. S.M. Sze (Ed), "VLSI Technology", McGraw Hill, 1998.
3. Hrundle, Evans, Wilson, "Encyclopedia of Material Characterization", Elsevier, 2005
4. D. K. Schroder, "Semiconductor Material and Device Characterization", Wiley Interscience, 2016
5. James Plummer, M. Deal and P.Griffin, "Silicon VLSI Technology", Prentice Hall, 2016
6. Rebeiz, G.M., RF MEMS: Theory Design and Technology, Wiley 2004
7. Stephen A. Campbell, "Fabrication engineering at the Mocto- and NanoScale", 4th edition Oxford University Press, 2013.

4. Additional Resources

1. Relevant Journals and Conference publications.

CORE COURSES: SEMESTER – II

M.Tech. I (Communication systems) Semester – II

Image Processing And Computer Vision

L	T	P	Credit
3	0	0	03

ECCS102 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Understand the basics of image formation, image processing and apply image enhancement both in spatial and frequency domains.
CO2	Analyse causes for image degradation and apply restoration techniques.
CO3	Evaluate different image segmentation techniques and develop solutions using Mathematical morphology concepts.
CO4	Understand the image representation and description techniques.
CO5	Analyse and evaluate different reflectance models and techniques to reconstruct 3D surfaces from 2D Images.

2. Syllabus:

IMAGE PROCESSING SYSTEM (04 Hours)

Camera Model, Image Representation, Image Sampling, Quantization, Resolution, Human Visual System, Classification of Digital Images, Image Types, Elements of an Image-processing System, Image File Formats, Relationships Between Pixels-Nearest Neighbour, Adjacency, Connectivity, Regions, and Boundaries; Distance Measures.

IMAGE ENHANCEMENT & IMAGE TRANSFORMS (10 Hours)

Image Enhancement in spatial domain, Enhancement through Point Operation, Histogram Manipulation, Gray-level Transformation, Neighbourhood Operation, filtering operation in spatial domain, Bit-plane Slicing, Enhancement in the Frequency Domain,2D Convolution, 2D Discrete Fourier Transform, Homomorphic Filter, Zooming Operation,

IMAGE RESTORATION/DENOISING AND IMAGE REPRESENTATION & DESCRIPTION (10 Hours)

Linear, Position-Invariant Degradations, Estimating the Degradation Function, Inverse Filtering, Minimum Mean Square Error (Wiener) Filtering, Constrained Least Squares Filtering Classification of Noise in Image, Median Filtering, Trimmed Average Filter, Adaptive filters, Performance Metrics in Image Restoration, Applications of Digital Image Restoration. Image Image Compression Fundamentals, study of Image representation and description techniques.

IMAGE SEGMENTATION AND MATHEMATICAL MORPHOLOGY (06 Hours)

Point, Line, and Edge Detection, Thresholding, Region-Based Segmentation, Basic Morphological Operations-Opening, Closing Operators, Dilation and Erosion, Morphological Algorithms, Applications.

IMAGE FORMATION **(05 Hours)**

Pinhole and Perspective Projection, Image Magnification, Vanishing Point, Image Formation using Lenses, Gaussian Lens Law, Focal Length, Two Lens System, Aperture of the Lens, Lens Defocus, Blur Circle, Depth of Field, Lens Related Issues.

RECONSTRUCTION **(10 Hours)**

Light Flux, Radiant Intensity, Surface Irradiance, Scene Radiance, BRDF, Reflectance Models, Surface Orientation, Reflectance Map, Photometric Stereo, Shape from Shading, Depth from Focus, Depth from Defocus.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. R. C. Gonzalez, R. E. Woods, Digital Image Processing, Pearson Education. 4rd Ed.,2017
2. Jain A.K., Fundamentals of Digital Image Processing, Prentice-Hall, 2002.
3. Sonka M. Hlavac V., Boyle R., Image Processing, Analysis and Machine Vision, Cengage Learning, 2nd Ed. Indian Reprint, 2009.
4. Manas Kamal Bhuyan, Computer Vision and Image Processing Fundamentals and Applications, Taylor & Francis, CRC Press, 2020.
5. Pratt W.K., Digital Image Processing, John Wiley, IV Edition, 2007.
6. Berthold Horn, Robot vision, MIT press, 1986.
7. Richard Hartley, Andrew Zisserman, Multiple view geometry in computer vision, Cambridge university press, 2003.

M.Tech. I (Communication systems) Semester – II

Wireless Communications

L	T	P	Credit
3	0	0	03

ECCS104 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe and classify the channel models, modulation schemes like spread spectrum and multicarrier modulation.
CO2	Demonstrate the concept of spread spectrum technology, multicarrier modulation scheme, OFDM and MIMO to develop a wireless communication link.
CO3	Analyze the impact of various types of fading (large-scale, shadowing, and small-scale) on wireless communication systems and propose mitigation techniques.
CO4	Evaluate the performance of different modulation schemes in terms of bit error rate and signal quality in varying environments.
CO5	Design and simulate a wireless communication system incorporating advanced techniques like spread spectrum, OFDM and MIMO to address real-world communication challenges.

2. Syllabus:

GENERAL CONSIDERATIONS **(10 Hours)**

General considerations about radio waves over wireless channel, Radio wave propagation and the atmosphere, basic propagation mechanisms, classification of fading channels, large scale fading, shadowing, small-scale fading and multipath, statistics of fading coefficient, BER of wired and wireless communication system, diversity, power profile, delay spread, coherence bandwidth, Doppler, Doppler spectrum.

SPREAD SPECTRUM MODULATION **(12 Hours)**

Basic principle of Orthogonality, spreading code, CDMA, generation and properties of PN sequence, random spreading sequence and their properties, advantages of CDMA, rake receiver, performance analysis of CDMA downlink and uplink scenarios, near far problem in CDMA

Multi-carrier Modulation and OFDM **(13 Hours)**

Introduction to Multicarrier modulation, multicarrier transmission and reception scheme, bottleneck in multi-carrier modulation scheme, introduction to OFDM, OFDM transmission and reception schemes, cyclic prefix, carrier frequency offset in OFDM, PAPR in OFDM, SC-FDMA.

MIMO **(10 Hours)**

Introduction spatial multiplexing, MIMO system model, zero forcing receiver, MIMO-MMSE receiver, SVD based optimal MIMO transmission and reception, optimal power allocation in MIMO, space time coding, Non-linear MIMO receiver-V-BLAST, MIMO beam forming, MIMO-OFDM

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. T. S. Rappaport, “Wireless Communications: Principles and Practice”, Pearson Education, 2nd Edition, 2010.
2. Molisch Andreas F, “Wireless Communications”, Wiley, 2nd Edition, 2011.
3. Goldsmith Andrea, “Wireless Communications”, Cambridge University Press,2002.
4. Yong Soo Cho, Jaekwon Kim, Won Young Yang, and Chung G. Kang, "MIMO-OFDM Wireless Communications with MATLAB" Wiley, 1st Edition, 2010.
5. Upena Dalal, “Wireless Communication”, Oxford University Press, 1st Edition, 2008.

M.Tech. I (Communication systems) Semester – II

Communication Lab – II

L	T	P	Credit
0	0	6	03

ECCS106 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Review of basic fundamental concepts of a digital image processing.
CO2	Implement the techniques for image enhancement and techniques for spatial and frequency domain processing restoration techniques and morphological techniques
CO3	Explain and analyze wired and wireless channel models and their impact on wireless
CO4	Apply the principles of spread spectrum communication and CDMA to design and evaluate wireless communication systems.
CO5	Evaluate and design advanced wireless communication techniques such as OFDM and MIMO for optimizing performance in practical scenarios.

2. List of Experiments

Image Processing and Computer Vision

01) Spatial Gray Level Resolution and Zooming, Shrinking, Bilinear Interpolation
02) Creation of Negative Image and Gamma Correction
03) Thresholding Applied to Image
04) Bit Plane Slicing of an Image
05) Histogram Equalization and Matching for B/W and Color Images, Finding Mean and Variance
06) Noise Generation in The Image Using Gaussian Noise and Salt & Pepper Noise, Finding Mean and Variance
07) Noise Reduction Using Median Filter
08) Periodic Noise Reduction Using Notch Filter
09) High Pass and Low Pass Filter Applied to Image
10) Function Implementation for Reading, Writing & Rotating Images
11) Point Detection and Edge Detection of the Image
12) Correlation Between Two Images
13) Pseudo Color Processing

Wireless Communication

01) Assess the Bit Error Rate (BER) Performance of Digitally Modulated Symbols Under Additive White Gaussian Noise (AWGN) for Different Signal-to-Noise Ratios (SNR).
02) Estimate the Path Loss Exponent for a Wireless Communication System Using the Minimum Mean Square Error (MMSE) Method (Linear Regression).
03) Evaluate and Compare the BER Performance of Wired and Wireless Communication Systems Under Varying SNR Conditions.

04) Evaluate and Compare the Performance of Diversity Techniques in a Wireless Communication System Under Varying SNR Conditions.

05) Implement and Assess the Performance of a Code Division Multiple Access (CDMA) Transmitter and Receiver.

06) Implement a Rake Receiver for CDMA and Evaluate Its Performance.

07) Implement a Multicarrier Modulation (MCM) Transmitter and Receiver and Analyze their Performance.

08) Implement an Orthogonal Frequency Division Multiplexing (OFDM) Transmitter and Receiver and Evaluate Their Performance.

09) Implement a Single Carrier Frequency Division Multiple Access (SC-FDMA) Transmitter and Receiver and Assess Its Performance.

10) Implement a Multiple Input Multiple Output (MIMO) Communication System Using Zero Forcing and Minimum Mean Square Error (MMSE) Receivers, and Evaluate their Performance.

(Total Contact Time: 90 Hours)

M.Tech. I (Communication systems) Semester – II

Mini Project

L	T	P	Credit
0	0	4	02

ECCS108 **Scheme**

1. <u>Course Outcomes (COs):</u>

At the end of the students will be able to:

CO1	Explain the plan of action prototype system that addresses a specific problem or requirement within the domain of communication systems.
CO2	Understand and modify design (for existing product) including all aspects of products , material, process, resources and standards etc.
CO3	Analyse and validate software and hardware selection.
CO4	Evaluate effectiveness of practicality with respect to industry level implementation of the prototype system involving system design aspect.
CO5	Design prototype with experimental result, future scalability considerations of the developed prototype and Implement final working model/software.

(Total Contact Time: 60 Hours)

ELECTIVE COURSES- III, IV & V: SEMESTER – II

M.Tech. I (Communication systems) Semester – II

Deep Learning Theory and Practice

L	T	P	Credit
3	0	0	03

ECCS172 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Explain the basic concepts in Neural Networks and applications.
CO2	Understand general terms and background of deep learning and to know the main techniques in deep learning.
CO3	Implement deep neural network system.
CO4	Identify the deep learning algorithms which are more appropriate for various types of learning tasks in various domains.
CO5	Design deep learning algorithms and solve real-world problems.

2. Syllabus:

INTRODUCTION **(09 Hours)**

Introduction to Deep Learning, Bayesian Learning, Decision Surfaces, Linear Classifiers, Linear Machines with Hinge Loss, Optimization Techniques, Gradient Descent, Batch Optimization

NEURAL NETWORK **(09 Hours)**

Introduction to Neural Network, Multilayer Perceptron, Back Propagation Learning, Unsupervised Learning with Deep Network, Auto encoders

CONVOLUTIONAL NEURAL NETWORKS **(10 Hours)**

Convolutional Neural Network, Building blocks of CNN, Transfer Learning, Revisiting Gradient Descent, Momentum Optimizer, RMSProp, Adam, Effective training in DeepNet- early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization

DEEP LEARNING **(10 Hours)**

Recent Trends in Deep Learning Architectures, Residual Network, Skip Connection Network, Fully Connected CNN etc., Classical Supervised Tasks with Deep Learning, Image Denoising, Semantic Segmentation, Object Detection etc.

LSTM AND GENERATIVE MODELS **(07 Hours)**

LSTM Networks Generative Modeling with DL, Variational Autoencoder, Generative Adversarial Network Revisiting Gradient Descent, Momentum Optimizer, RMSProp, Adam

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Deep Learning- Ian Goodfelllow, Yoshua Benjio, Aaron Courville, The MIT Press. Year 2023
2. Understanding Machine Learning: From Theory to Algorithms by Shai Shalev-Shwartz, Shai Ben-David, Year 2014

3. Pattern Classification- Richard O. Duda, Peter E. Hart, David G. Stork, John Wiley & Sons Inc. Year 2012
4. Yegnanarayana, B., Artificial Neural Networks PHI Learning Pvt. Ltd, 2009.
5. Golub, G., H., and Van Loan,C.,F., Matrix Computations, JHU Press,2013.
6. Satish Kumar, Neural Networks: A Classroom Approach, Tata McGraw-Hill Education, 2004

M.Tech. I (Communication systems) Semester – II

Internet of Things, Technologies and Applications

L	T	P	Credit
3	0	0	03

ECCS174 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe sensor data available on the Internet for analysis and visualization.
CO2	Demonstrate basic measurement tools to determine the real-time performance of packet-based networks.
CO3	Examine how to communicate with other mobile devices using various communication platforms such as Bluetooth and Wi-Fi.
CO4	Evaluate trade-offs in interconnected wireless embedded sensor networks.
CO5	Create end-to-end IoT applications, working as a team.

2. Syllabus:

INTRODUCTION TO IOT **(06 Hours)**

IOT Architecture, Major components of IoT, IoT Design Methodologies, IoT Entities, IOT Software Development Platforms (Python/C/C++), Data acquisition: Sensors, Actuators, Gateways, Cloud, Mobile/Web Applications

MACHINE-TO-MACHINE COMMUNICATIONS **(09 Hours)**

Wired Communication Protocols, Role of M2M in IoT, Machine-to-Machine Communication: IEEE 802.15.4, Zigbee, Z-Wave, MQTT/MQTT-SN, COAP, 6LoWPAN, RPL.

NETWORKING IN IOT **(09 Hours)**

Real-time networking, Soft and real time, quality of service/information, resource reservation and scheduling, and performance measurements, Introduction to SDN, SDN and NFV for IoT

COMPUTING IN IOT **(08 Hours)**

Data Handling and Analytics, Cloud Computing, Sensor-Cloud, Fog Computing, IoT Security

IOT SYSTEM DESIGN **(07 Hours)**

Logical Design using Python, Linux-based Edge Device—Raspberry Pi, Integration of Sensors and Actuators with Arduino, Raspberri Pi, Tools for IoT

IOT SYSTEM DESIGN **(06 Hours)**

Logical Design using Python, Linux-based Edge Device—Raspberry Pi, Integration of Sensors and Actuators with Arduino, Raspberri Pi, Tools for IoT

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", 1st Ed., CRC Press, 2017.
2. ArshdeepBahga and Vijay Madisetti, "Internet of Things: A Hands-on Approach", 1st Ed., Universities Press, x 2014.
3. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos and David Boyle, “From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence”, 1st Ed., Academic Press, 2014.
4. Simone Cirani, Gianluigi Ferrari,Marco Picone, Luca Veltri, “Internet of Things Architectures, Protocols and Standards”, Wiley, 2019.
5. Rahul Dubey, “An Introduction to Internet of Things: Connecting Devices, Edge Gateway, and Cloud with Applications”, 1st Ed., 2019.

M.Tech. I (Communication systems) Semester – II

Optical Networks

L	T	P	Credit
3	0	0	03

ECCS112 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Classify the Architectures of the Client Layers in Optical Layer, Frame Structures and Protocols. for Optical Networks
CO2	Comprehend PON and FSO Technologies and their Components to Compute Range Budget For These Networks.
CO3	Apply the Network Control And Management Strategies to Wavelength Routed Optical Networks.
CO4	Evaluate Protection in SONET/SDH, Point-To-Point Links, Ring Interconnection Protection in The Client Layers
CO5	Analyse OTDM, Optical AND Gates, OPS, Optical PLL, Tuneable Delays For Future Optical Networks.

2. Syllabus:

INTRODUCTION **(06 Hours)**

Network terminologies, OSI model, Telecommunications Network Architecture, Services: Circuit Switching, and Packet Switching, Multiplexing Techniques, Second-Generation Optical Networks, The Optical Layer, Transparency and Network Evolution, WDM Networking Evolution, Point-to-Point WDM Systems, Wavelength Add/Drop Multiplexer (WADM), Fiber and Wavelength Cross connects, Broadcast-and-Select Networks, Wavelength-Routed (Wide-Area) Optical Network, WDM Economics.

OPTICAL METRO AND TRANSPORT NETWORKS **(07 Hours)**

Client Layers of the Optical Layer, SONET/SDH, Multiplexing, SONET/SDH Layers, Optical Transport Network, ATM, FDDI, Ethernet, IP, OTN.

OPTICAL ACCESS NETWORKS **(06 Hours)**

Fibber to the Curb (FTTC), PON Evolution, PON Technologies, OLT, Splitters, ONU, PON Range Budget, TPON, GPON, WDM PON and other Networks, Free Space optics (FSO), Free Space Optical Networks.

WAVELENGTH ROUTED OPTICAL NETWORKS **(05 Hours)**

Optical Routers and Optical Switches, Wavelength continuity constraint, Basics of Wavelength Conversion, Wavelength Conversion Techniques, Optoelectronic Approach, Optical Gating, Interferometric Technique, Wave Mixing, Converter Switches.

NETWORK CONTROL AND MANAGEMENT **(08 Hours)**

Basic Functions of Network Control and Management, Dynamic Routing and Wavelength Assignment, Fixed Routing and Fixed-Alternate-Path Routing, Adaptive Routing Based on Global Information, Adaptive Routing Based on Neighborhood Information, Adaptive Routing Based on Local Information, various resource reservation techniques and fault management.

NETWORK SURVIVABILITY **(07 Hours)**

Basic Concepts, Protection and Restoration, Protection in SONET/SDH, Point-to-Point Links, Ring Interconnection Protection in the Client Layers: Resilient Packet Rings, Ethernet, MPLS, IP etc., Optical Layer Protection Schemes, GMPLS Protection.

FUTURE OPTICAL NETWORKS **(06 Hours)**

Photonic Packet Switching (OPS) Optical Time Division Multiplexing (OTDM), Bit Interleaving, Packet Interleaving, Optical AND Gates, Synchronization, Tunable Delays, Optical Phase Lock Loop, Optical Packet Switching (OPS) and Optical Burst Switching.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Ramaswami Rajiv and Sivarajan K. N., "Optical Networks: A Practical Perspective", Elsevier, Morgan Kaufmann Publishers, 3rd Ed., 2012..
2. Biswanath Mukherjee, “Optical WDM Networks”, 1st Ed., Springer; 2006.
3. Hemani Kaushal, V.K. Jain, SubratKar, “Free Space Optical Communication”, 1st Ed., Springer, 2017.
4. Volkmar Bruckner, “Elements of Optical Networking, Basics and Practice of Glass Fiber Optical Data Communication” , Springer Vieweg 2nd Edition 2024
5. C. S. Murthy & M. Gurusamy, “WDM Optical Networks”, 1st Ed., PHI, 2002.

M.Tech. I (Communication systems) Semester – II

Estimation & Detection Theory

L	T	P	Credit
3	0	0	03

ECCS114 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe the basic concepts of signal estimation and linear prediction.
CO2	Apply estimation algorithms for engineering problems
CO3	Analyse performance of different estimation algorithms.
CO4	Evaluate performance of estimation algorithms.
CO5	Design estimator for the problems of interest.

2. Syllabus:

LINEAR PREDICTION (19 Hours)

Linear Prediction and Optimum Linear Filters, Forward and Backward Linear Prediction, Solution of The Normal Equations-Levinson-Durbin and Schur Algo, Pede's Approximation, AR Lattice and ARMA Process and Lattice Ladder Filter, Wiener Filter, Kalman Filter, Adaptive Filter, Linear Mean Square Estimation, Estimation Error, Least Square Errors, Minimum Mean Square Error.

ESTIMATION (09 Hours)

Estimation Based on Statistical Analysis, Bayesian Estimation, MAP and ML Detection Rules, Cramer-Rao Inequality.

SPECTRUM ESTIMATION (05 Hours)

APPLICATIONS OF ESTIMATION THEORY (13 Hours)

Wireless Channel Estimation, Pilot Based and Training Sequence Based Estimation And Blind Estimation, Estimation Theory Applied For Speech, Image And Video Compression Coding, Time Delay Estimation, Velocity Estimation, Detection of Signal In Gaussian Noise.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Steven M. Key, "Fundamentals of Statistical Signal Processing (Volume II): Detection Theory", 3rd Ed., Prentice Hall PTR, Reprint 2022
2. Steven M. Key, "Fundamentals of Statistical Signal Processing (Volume I): Estimation Theory", 3rd Ed., Prentice Hall PTR, reprint 2012
3. Anderson B. D. O and Moore J. B.,"Optimal Filtering",Prentice-Hall,1981

4. Ljung L.,“System Identification Theory For The User”,Prentice-Hall,2006
5. Maybeck P. S.,“Stochastic Models, Estimation And Control, Vol. 1, 2, 3”,Academic Press,1999
6. Saeed V. Vaseghi,“Advanced Digital Signal Processing And Noise Reduction”, Wiley, 2nd Edition,2008.
7. Monson Hayes,“Statistical Digital Signal Processing And Modeling”, John Wiley & Sons Inc., 1st Edition,2002
8. Proakis John and Manolakis,“Digital Signal Processing”,Prentice-Hall, 3rd Edition, 2007

M.Tech. I (Communication systems) Semester – II		**L**	**T**	**P**	**Credit**
Microwave Integrated Circuits		**3**	**0**	**0**	**03**

ECCS116 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Define the various attributes of different types of transmission lines
CO2	Classify the different types of transmission lines, matching networks and circuits
CO3	Apply the knowledge of all aspects, design factors and properties of MICs.
CO4	Analyze the behaviour of MIC and their noise model.
CO5	Evaluate/Determine the working and design parameters of MIC, mixers, oscillators, amplifiers.

2. Syllabus:

INTRODUCTION TO MICROWAVE INTEGRATED CIRCUITS (03 Hours)

Introduction to Monolithic Microwave Integrated Circuits (MMICs), their advantages over discrete circuits, MMIC fabrication techniques, thick and thin film technologies and materials, encapsulation and mounting of active devices, Microstrips on semiconductor substrates.

MICRO-STRIP LINES (03 Hours)

Planar transmission lines for MICs. Method of Conformal transformation for microstrip analysis, concept of effective dielectric constant, Effective dielectric constant for microstrip, Losses in Microstrip.

SLOT LINES (04 Hours)

Slot Line Approximate analysis and field distribution, Transverse resonance method and evaluation of slot line impedance, comparison with Microstrip line.

FINE LINES AND COPLANAR LINES (03 Hours)

Conventional TCP/IP Protocols, Indirect TCP, Snooping TCP, Mobile TCP, Other Transport Layer Protocols for Mobile Networks, Flow control, Congestion control, Error Control.

LUMPED ELEMENTS FOR MICS (04 Hours)

Use of Lumped Elements, Capacitive elements, Inductive elements, and Resistive elements.

MATCHING AND BIASING NETWORKS (03 Hours)

Impedance Matching using Discrete Components, Microstrip Line Matching Networks

FUNDAMENTALSOF CMOS TRANSISTORS FOR RFIC DESIGN (05 Hours)

MOSFET Basics, MOSFET Models, Fundamentals of Stability, Determination of Stable and Unstable Regions, Stability Consideration for N-Port Circuits, Noise Figure Circles, Constant VSWR Circles. Broadband, High Power and Multistage Amplifiers, Low Noise Amplifier Design.

MICROWAVE IC DESIGN AND MEASUREMENT TECHNIQUES **(05 Hours)**

MIC Measurement, Testing and Applications: MIC measurement system, measurement techniques – S parameter measurement, noise measurement, MIC applications.

SUBSTRATE INTEGRATED CIRCUITS **(07 Hours)**

Substrate Integrated Waveguide, Substrate Integrated Image Guide, Substrate Integrated Non-radiative Dielectric Guide, Substrate Integrated Feeding Network, Substrate Integrated Divider, Substrate Integrated Phase Shifter, Substrate Integrated Coupler, Substrate Integrated Circuit–Related Transition.

METAMATERIAL-BASED COMPACT MICROWAVE AND MILLIMETRE WAVE CIRCUIT DESIGN **(08 Hours)**

Designs of True-Time-Delay Lines and Phase Shifters based on CRLH TL Unit Cells, Perfect Metamaterial Absorbers in Microwave and Terahertz Bands, Metamaterial-Based Compact Filter Design, Magnetically Tunable Unidirectional Electromagnetic Devices Based on Magnetic Surface Plasmon, Compact Coplanar Waveguide Metamaterial-Inspired Lines and its use in Highly Selective and Tunable Bandpass Filters.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. K.C. Gupta, "Microwave Integrated Circuits", 1st Ed., Wiley eastern Pvt. Ltd., 1975.
2. K.C. Gupta, R. Garg, I. J. Bahl, "Microstrip Lines and Slot Lines", 1st Ed., Artech House.
3. T. H. Lee, "The Design of CMOS radio Frequency Integrated Circuits", 2nd Ed., Cambridge, 2004.
4. Xun-Ya Jiang, "Metamaterials" 1st Ed., Intech, 2012.
5. Yu Jian Cheng, "Substrate Integrated Antennas and Arrays", 1st Ed., CRC Press, 2016.

4. REFERANCE BOOK

1. Bharathi Bhat, Shiban Koul, "Stripline-like transmission Lines for Microwave Integrated Ciruits", 1st Ed., New Age International (P) Ltd. Publishers, 2007
2. Ricardo Marques, Ferran Martin, Mario Sorolla, "Materials with Negative Parameters", 1st Ed., Wiley Interscience, 2001.
3. David M. Pozar, "Microwave Engineering", 4th Ed., John Wiley & Sons, 2011

M.Tech. I (Communication systems) Semester – II

Photonic Integrated Devices and Systems

L	T	P	Credit
3	0	0	03

ECCS118 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe the working and construction of various Acoustic optic devices and their fabrication.
CO2	Apply the concept of the optical waveguides to analyze different coupling methods.
CO3	Analyze the advanced optical sources and detectors, OIC and monolithic systems.
CO4	Evaluate the parameters for optical sensors for different types of measurements
CO5	Design Bio photonic applications of micro and Nano photonics.

2. Syllabus:

OPTICAL WAVEGUIDE THEORY **(07 Hours)**

Planar waveguides: Step-index and graded-index waveguides, guided and radiation modes. Strip and channel waveguides, anisotropic waveguides, segmented waveguide; electro-optic and acousto-optic waveguide devices.

ACOUSTO OPTIC DEVICES AND FABRICATION **(08 Hours)**

Directional couplers, optical switch; phase and amplitude modulators, filters, etc. junction, power splitters, Arrayed waveguide devices, fiber pig tailing, Fabrication of integrated optical waveguides and devices

WAVEGUIDE CHARATERIZATION **(09 Hours)**

Waveguide characterization, end-fire and prism coupling; grating and tapered couplers, nonlinear effects in integrated optical waveguides.

NEW MATERIALS AND PROCESS TECHNOLOGIES **(08 Hours)**

New materials and process technologies for optical device fabrication, advanced optical sources & detectors, amplifiers, their reliability issues, Optical integrated circuits, hybrid & monolithic systems, optical inter-connects, materials and processing for OEIC.

OPTICAL SENSORS **(07 Hours)**

Optical sensors intrinsic & extrinsic, principles of pressure, temperature, displacement and velocity measurements

ADVANCED TOPICS MICRO AND NANOPHOTONICS **(06 Hours)**

Photonic crystals and MOEMS, Bio-photonic applications, recent developments in PICs.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Robert Hansberger, “Integrated optics: Theory and technology” 6th Ed., Springer, 2009.
2. T. Tamir, “Guided wave opto-electronics' ', 2nd Ed., Springer Verilag, 1990.
3. H. Nishihara, M. Haruna, and T. Suhara, “Optical Integrated Circuits”, 1st Ed., McGraw-Hill Professional, 1989.
4. Yariv, A., & Yeh, P. “Photonics: Optical Electronics in Modern Communications”, 6th Ed., Oxford university Press (2006).
5. Madeleine Glick, Ling Liao, Katharine Schmidtke, “Integrated Photonics for Data Communication Applications” Elsevier, 1st Edition - July 26, 2023,

M.Tech. I (Communication systems) Semester – II

Ad-Hoc Networks

L	T	P	Credit
3	0	0	03

ECCS120 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Show the basic knowledge of architecture, issues, protocols of Mobile Adhoc Networks and the standard Adhoc networks-Bluetooth, WiFI, WiMax, WSN etc.
CO2	Explain differences between fixed and Adhoc network protocols, mobility constraints and dynamic approaches in Adhoc Networks.
CO3	Apply protocols and techniques in MANETs, developing algorithms for recent standard Adhoc networks overcoming the constraints
CO4	Evaluate various techniques and protocols/algorithms, case study and problem solving as per given data.

2. Syllabus:

INTRODUCTION **(04 Hours)**

Introduction To Generations In Wireless Systems, Introduction To Mobile Ad-Hoc Networks (MANETS), Classification Of Mobile Data Networks, MANET issues, Wireless Channel Related Issues

MAC LAYER ISSUES OF ADHOC NETWORKS **(04 Hours)**

CSMA with Hidden and Exposed Terminal Issues, MACA and MACAW protocols

NETWORK LAYER ISSUES IN ADHOC NETWORKS **(06 Hours)**

Challenges, Proactive and Reactive Algorithms, Limitations of Bellman Ford Algorithm, DSDV, WRP, CGSR protocols, DSR, AODV, Location aided, hybrid protocols, multicast protocols

TRANSPORT LAYER ISSUES **(06 Hours)**

Challenges, data flow control mechanisms, congestion control protocols, security aspects

BLUETOOTH **(06 Hours)**

Bluetooth Network Structure: Piconet & Scatternet, Bluetooth Specifications, Bluetooth Protocol Stack, Bluetooth Media Access Control Consideration, Asynchronous Connectionless And Synchronous Connection Oriented Communication Link, Modified Bluetooth

WIFI - IEEE802.11 STANDARDS **(04 Hours)**

Various 802.11 Protocols (a to s), WiFi Architecture, Security Enhancement, QoS Enhancement, Physical & MAC Layer Aspects Of 802.11 a,b,g,n; WiFi MAC: Point Coordinate Function, Distributed Coordinate Function, Hybrid Coordinate Function

WiMAX - IEEE802.16 STANDARDS **(05 Hours)**

Various 802.16 (a to e) Protocols, WiMAX Air Interface / Physical Layer, WiMAX Architecture, WiMAX Protocol Architecture, WiMAX And WiFi Interworking, WiMAX Mode: TDD And FDD, QoS In WiMAX

WIRELESS SENSOR NETWORK **(06 Hours)**

Sensor node architecture, Sensor Network architecture, Zigbee IEEE 802.15.4, Mobile Computing Aspects, Introduction to IoT

UWB **(02 Hours)**

UWB Air Interface

IEEE802.20 AND BEYOND **(02 Hours)**

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. C.Siva RamaMurthy, B.S.manoj, “Adhoc Wireless Networks-Architectures and Protocols”, Pearson, 1st Ed 2007
2. Toh C. K.“Ad-hoc Mobile Wireless Networks-Protocol and Systems”, LPE, Pearson Education, 2nd Edition, 2009
3. Upena Dalal,“Wireless Communication”, Oxford University, 1st Edition, 2009
4. Taieb Znati, Kazem Sohraby, Daniel Minoli, “Wireless Sensor Networks: Technology, Protocols and Applications, Wiley publications, 1st Edition, January 2010
5. Sudip Misra, Isaac Woungang, Subhas Chandra Misra (Editors) “Guide to Wireless Adhoc Networks” Springerlink, 2009 (Open Access)
6. Jonathan Loo, Jesus Hamilton Ortiz, Jaime Lloret Mauri (Editors), “Mobile Adhoc Networks”, CRC Press, 1st Edition, 2012 (Open Access)

M.Tech. I (Communication systems) Semester – II

MIMO Technology

L	T	P	Credit
3	0	0	03

ECCS122 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe basic terminologies associated with MIMO technology and understand the advancements in the technology.
CO2	Apply the developed fading concepts in MIMO system analysis.
CO3	Analyse various performance metrices for MIMO System.
CO4	Evaluate performance trade-offs in MIMO technology.
CO5	Design space time codes and optimum MIMO Communication systems under given conditions.

2. Syllabus:

INTRODUCTION TO MULTI ANTENNA SYSTEM (03 Hours)

Need for MIMO Systems, MIMO wireless communication, Benefits of MIMO technology, Basic Building Block, MIMO channel & signal model, Error/Outage Probabilities over fading channels, Multiple antennas in wireless Communication, A fundamental Trade-off, MIMO transceiver design, Applications of MIMO systems.

CLASSICAL AND GENERALIZED FADING DISTRIBUTIONS (07 Hours)

Introduction to fading distributions, Classical fading distributions, Generalized fading distributions

MIMO CHANNEL MODELLING (08 Hours)

Physical channel modelling: Electromagnetic Models, Geometry Based Models, Empirical Models,. Analytical MIMO channel modelling: Fully correlated MIMO channels, separately correlated MIMO channel model, Uncorrelated MIMO channel model.

MIMO CHANNEL CAPACITY (10 Hours)

Power allocation in MIMO System: Uniform, Adaptive and Near optimal power allocation, Capacity of simplified MIMO channels: Capacity for deterministic and random channels, Capacity of i.i.d., separately correlated and keyhole Raleyigh fading MIMO channel.

SPACE TIME CODES (08 Hours)

Design criteria for space time codes, Transmit Diversity for two antennas: The Alamouti Scheme-Transmission scheme, Optimal receiver for Alamouti Scheme, Performance analysis of Alamouti Scheme, Orthogonal Space Time Block codes (OSTBC), Space time trellis codes: Design principle, Representation of Space-Time trellis code for PSK constellations, Performance Analysis for Space-Time Trellis codes, Comparison of Space -Time Block & Trellis Codes.

MIMO DETECTION TECHNIQUES **(07 Hours)**

ML detection, Linear suboptimal detection: zero forcing and MMSE detection technique, Sphere decoding Advanced MIMO detection techniques: Successive Interference Cancellation, Lattice reduction-based detector

ADVANCE TOPICS IN MIMO WIRELESS COMMUNICATION **(02 Hours)**

Space time block coded spatial modulation, MIMO based cooperative communication, Large scale MIMO systems, MIMO cognitive radios

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Rakesh Singh Kshetrimayum, “Fundamentals of MIMO Wireless Communications,” Cambridge University Press, 2017
2. Ezio Biglieri, R.Calderbank, Anthony C., Andrea Goldsmith, Arogyaswami Paulraj, H. Vincent Poor, “MIMO Wireless Communications”, Cambridge University Press, 2007.
3. H. Khaleghi Bizaki, “MIMO Systems, Theory and Applications”, Intech, 2011.
4. Mohinder Jankiraman, “Space-Time Codes and MIMO Systems”, Artech House, Boston, London, 2004.
5. Tolga m. Duman, Ali Ghrayeb, “Coding for MIMO Communication Systems”, 1st Ed., John Wiley & Sons Ltd., 2007.
6. Savo G. Glisic, “Advanced Wireless Communications”, John Wiley & Sons, 2007.

M.Tech. I (Communication systems) Semester – II

Global Navigation Satellite Systems

L	T	P	Credit
3	0	0	03

ECCS124 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Understand global as well regional navigation systems.
CO2	Apply knowledge of different signal and system structures of diverse navigation systems.
CO3	Analyze position of GNSS receiver using acquisition and tracking.
CO4	Evaluate various GNSS positioning techniques.
CO5	Design GNSS based solution for societal applications.

2. Syllabus:

INTRODUCTION TO GNSS **(06 Hours)**

Introduction to GNSS systems, GNSS terminologies, GNSS Architecture, Augmentation System, Various Navigation Systems: Global Navigation systems: GPS, GLONASS, GALILEO, Beidou Regional Navigation systems: QZSS, IRNSS/NavIC, GNSS System Architecture & Signals, Error correction coding, Navigation Message Structures, Frequency band allocation

GNSS SIGNAL STRUCTURE AND PROPAGATION **(09 Hours)**

Satellite orbits: MEO, GEO, GSO, visibility of satellites, Ranging stations, Power budget and received signal levels, Ionospheric and Tropospheric propagation of GNSS signals and introduced errors, Multipath propagation and introduced errors, Total Error budget, CNR of received signal, Interference from other GNSS signals, Spectrum of GNSS signals, PRN codes, baseband and passband structure and mathematical representation of GNSS signals.

NAVIGATION RECEIVERS **(11 Hours)**

Generalized GNSS Receiver Architecture, IF and baseband signal processing, IF/baseband filtering, Different Acquisition techniques, GNSS Signal Tracking, Signal tracking loops (DLL, PLL, FLL), Navigation Data Demodulation, Decoding and Processing, Measurement of pseudo range

POSITION DETERMINATION TECHNIQUES **(08 Hours)**

Principle of GNSS Operation: Satellite constellation and Dilution of Precision, Trilateration Concept, Ephemeris and Almanac, Determination of satellite position, velocity, visibility and ground tracks, Use of Pseudo-Ranges in Position Calculation: Estimation accuracy and precision of pseudo range, Position, Velocity and Time determination techniques, Errors in GNSS measurements and its mitigation

TECHNOLOGIES FOR ADVANCED RECEIVERS AND AUGMENTED SYSTEMS **(09 Hours)**

Jamming and Interference, GNSS Spoofing & Receiver Anti Spoofing Techniques, Challenges and techniques for weak signal acquisition and tracking, carrier measurement aiding, Dual frequency receivers, Basic Concepts of Differential GNSS (DGNSS), Real Time and Post Processing DGNSS: Real Time Kinematics (RTK), Need for Augmentation Systems, Satellite-Based Augmentation

Systems (SBAS), Ground-Based Augmentation Systems (GBAS), GNSS Networks, Signal properties and receiver processing of BOC-modulated navigation signals

APPLICATIONS OF GNSS **(04 Hours)**

Aviation Ground-based Augmentation, Marine Navigation, Space Navigation, Vehicle Navigation, Precision Agriculture, Military Applications, Geodesy, Surveying and Mapping, Atmospheric and Ionospheric Science

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. John W. Betz, "Engineering Satellite-based Navigational Timing", IEEE Press, 442 Hoes Lane, Piscataway, NJ 08854, 2015.
2. Elliott_D._Kaplan, Christopher_Hegarty "Understanding GPS Principles and Applications", 3rd Ed., Archtech House, Artech House, 2017.
3. Pratap Misra, Per Enge, "Global Positioning System_ Signals, Measurements, and Performance", 1st Ed., Ganga-Jamuna Press, 2006.
4. Scott Madry, "Global Navigation Satellite Systems and Their Applications", Springer series 10058, 2015.
5. Teunissen, Montenbruck, "Handbook of Global Navigation Satellite Systems", 1st Ed., Springer-Verlag, 2017.

M.Tech. I (Communication systems) Semester – II

Optical Wireless Communication

L	T	P	Credit
3	0	0	03

ECCS126 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe atmospheric channels for the intended terrestrial free space optical link
CO2	Apply the concepts of OWC to calculate the system performance under background noise effects.
CO3	Analyse various modulation/demodulation techniques in designing of transmitter/receiver for OWC system.
CO4	Compare various detection techniques under different atmospheric conditions
CO5	Evaluate the OWC system under different weather conditions.

2. Syllabus:

INTRODUCTION **(06 Hours)**

General introduction, optical channel - Beam divergence, atmospheric losses, weather condition influence, atmospheric turbulence effects viz., scintillation, beam wander, beam spreading, etc.

CHANNEL MODELLING **(08 Hours)**

Linear time invariant model, channel transfer function, optical transfer function, models of turbulence induced fading viz., lognormal, exponential, K distribution, I- distribution, gamma-gamma distribution, Optical wave models - Plane, spherical and Gaussian, range equation, transmitting and receiving antenna gains.

BACKGROUND NOISE EFFECTS **(07 Hours)**

Background noise source, detector FOV, diffraction limited FOV, spatial modes, background noise power calculation.

MODULATION TECHNIQUES **(08 Hours)**

Power efficiency, BW efficiency, bit versus symbol error rates, error rate evaluation for isochronous modulation schemes viz., M-PPM, OOK, mxn PAPM schemes, subcarrier modulation, an isochronous modulation schemes - DPPM, DHPIM, DAPPM, psd and bandwidth requirement.

DETECTION TECHNIQUES **(09 Hours)**

Photon counter, PIN/APD, PMT, coherent techniques viz., homodyne and heterodyne, bit error rate evaluation in presence of atmospheric turbulence, concept of adaptive threshold.

WEATHER IMPAIRMENTS **(07 Hours)**

Effect of turbulence and weather conditions viz., drizzle, haze fog on error performance and channel capacity, link availability.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Z. Ghassemlooy, W. Popoola, S. Rajbhandari, “Optical Wireless Communications”,2nd Ed., CRC Press, 2019.
2. L. C. Andrews, R.L.Phillips, “Laser Beam Propagation through Random Media”, 2nd Ed., SPIE Press, USA, 2005.
3. J. H. Franz, V. K. Jain, “Optical Communications: Components and Systems”, 1st Ed., Narosa Publishing House, 2000.
4. D. Chadha, “Terrestrial Wireless Optical Communication”, 1st Ed., Tata McGraw-Hill, 2012.
5. Ivan B. Djordjevic , “Advanced Optical and Wireless Communications Systems”, 2nd Edition, Springer, 2022.
6. Ramaswami Rajiv and Sivarajan K. N., "Optical Networks: A Practical Perspective", Elsevier, Morgan Kaufmann Publishers, 3rd Ed., 2012

M.Tech. I (Communication systems) Semester – II

5G Wireless Technologies

L	T	P	Credit
3	0	0	03

ECCS128 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Understand and describe the key components, architectures, technical specifications, functions of 5G wireless networks and interactions in enabling 5G services.
CO2	Compare and contrast different 5G radio access technologies (e.g., mMTC, URLLC, eMBB) and their applications and analyze their suitability for various applications, considering factors like latency, reliability, and data rate requirements.
CO3	Apply knowledge of 5G principles, channel models, propagation characteristics to solve basic network design problems, such as coverage planning or capacity estimation.
CO4	Analyze the trade-offs between different 5G deployment strategies and evaluate their suitability for various applications and environments
CO5	Design and simulate a basic 5G network solution for a given scenario, considering factors like coverage, capacity, path loss, fading, antenna configurations, cost, and user requirements.

2. Syllabus:

INTRODUCTION **(04 Hours)**

A vision for 5G, Key disruptive system concept trends; Performance limitations, new design principles, and three paradigm shifts; Critical usage scenarios in 5G: Crowded local access, Bursty IoT, Ultra-reliable and low latency communications; Spectrum: Spectrum for 4G, Spectrum challenges in 5G, 5G spectrum landscape and requirements.

5G RADIO ACCESS **(06 Hours)**

Evolution of mobile communication; 5G New Radio Access Technology; 5G NR Global view; NR-Physical Layer: Radio Protocol Architecture; NR PHY-Key Technology components: Modulation, Waveform, Multiple Antennas, Channel Coding; Physical Time Fr Resource; Physical signal; Duplexing scheme; Frame Structure; Physical Layer Challenges.

MULTICARRIER AND NR WAVEFORMS **(07 Hours)**

Multicarrier waveforms: OFDM based waveforms, Filterbank based waveforms; Single carrier DFTS-OFDM; NR Waveform: Waveform design requirements for 5G NR, Key performance indicator for NR waveform design, Waveform comparisons for NR; Suitability of OFDM for NR; Scalable OFDM for NR.

NEW 5G AIR INTERFACE: CHALLENGES FOR EFFICIENT MULTI-SERVICE COEXISTENCE **(06 Hours)**

Core services and their associated KPIs: Core services, Key performance indicators, KPI relevance to core services; Challenges for 5G design below 6 GHz: Design methodology, Service integration drivers, Link level and System level challenges.

5G WIRELESS CHANNEL AND PROPAGATIN MODELS **(06 Hours)**

Introduction; Modeling requirements and scenarios: Channel model requirements, Propagation scenarios; The METIS channel models: Map-based model, Stochastic model; Millimeter-wave channel experimental measurements and results interpretation; Quasi-deterministic approach for millimeter-wave channel modeling; Q-D channel models implementation.

5G ARCHITECTURE (06 Hours)

Introduction, NFV and SDN, Basics about RAN architecture; High-level requirements for the 5G architecture; Functional architecture and 5G flexibility; Integration of LTE and new air interface to fulfill 5G requirements, Physical architecture and 5G deployment.

MACHINE TYPE COMMUNICATION (02 Hours)

Use cases and categorization of MTC, MTC requirements; Fundamental techniques for MTC: Data and control for short packets, non-orthogonal access protocols; Massive MTC.

DEVICE TO DEVICE COMMUNICATION (03 Hours)

D2D from 4G to 5G: D2D standardization: 4G LTE D2D, D2D in 5G: research challenges; Radio resource management for mobile broadband D2D, RRM techniques for mobile broadband D2D, RRM and system design for D2D, 5G D2D RRM concept.

mmWAVE COMMUNICATION (03 Hours)

Spectrum and regulations; Channel propagation; Hardware technologies for mmW systems; Deployment scenarios; Architecture and mobility: Dual connectivity, Mobility, Beamforming, Beam finding; Physical layer techniques: Duplex scheme, Transmission schemes.

WIRELESS BEYOND 5G (02 Hours)

A vision for wireless beyond 5G; Expectations and challenges for wireless beyond 5G: Joint Communication and Sensing, Space-Air-Ground Communication, Semantic Communication, Data-Driven Communication System Design.

(Total Contact Time: 45 Hours)

3. <u>BOOKS RECOMMENDED</u>

1. Angeliki Alexiou, "5G Wireless Technologies", 1st Edition, The Institution of Engineering and Technology, 2017.
2. Afif Osseiran, Jose F. Monserrat, Patrick Marsch, "5G Mobile and Wireless Communication Technologies, Cambridge University Press, 2016.
3. Ali Zaidi, Fredrik Athley, Jonas Medbo, Ulf Gustavsson, Giuseppe Durisi, Xiaoming Chen, "5G Physical Layer, Principles, Models and Technology, Components, Academic Press, 2018.
4. Saad Z. Asif, "5G Mobile Communications: Concepts and Technologies", CRC Press, 2019.
5. Hrishikesh Venkatarman and Ramona Trestian, "5G Radio Access Networks: Centralized RAN, Cloud-RAN and Virtualization of Small Cells", CRC Press, 2017.

M.Tech. I (Communication systems) Semester – II

Speech Processing and Applications

L	T	P	Credit
3	0	0	03

ECCS130 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Define the fundamentals of speech processing.
CO2	Describe the different parameters of speech signal.
CO3	Apply different algorithm to extract different speech parameters.
CO4	Analyze different speech processing algorithm.
CO5	Design a speech based system for different applications.

2. Syllabus:

INTRODUCTION **(05 Hours)**

Speech processing applications, Stationary and non-stationary signal, Stationary and non-stationary analysis of speech signal, Representation of speech signal.

SPEECH FUNDAMENTAL **(06 Hours)**

Basic concepts: speech production and speech perception, Speech production model, Articulatory phonetics and speech sounds, Pitch frequency and Formant frequency, Speech segmentation: voiced, unvoiced and silence, vowel, semi-vowel, consonants, diphthongs, nasal etc.

TIME DOMAIN ANALYSIS OF SPEECH SIGNAL **(06 Hours)**

Short-term processing of speech signal, Window function, Time domain analysis, Short-time energy, Short-time autocorrelation, Short-time zero crossing, Pitch estimation, Speech vs silence classification based on short-time energy and zero crossing rate.

FREQUENCY DOMAIN ANALSIS OF SPEECH SIGNAL **(06 Hours)**

Discrete Fourier Transform, Short-term Fourier transform (STFT), Filter-bank analysis, Spectrogram analysis, Cepstrum analysis, Pitch and formant estimation

LINEAR PREDICTION ANALYSIS **(10 Hours)**

Prediction, Linear prediction, Prediction model: All pole model and Pole zero model; Autocorrelation and covariance method; Levinson-Durbin algorithm; Inverse filtering; LP residual; Pitch frequency and formant frequency analysis using LP analysis.

SPEECH PATHOLOGY DETECTION **(06 Hours)**

Feature investigation, Feature extraction: Mel frequency cepstral coefficient (MFCC) and Linear prediction coefficient (LPC), Nonlinear features, Modelling (training/classification) based on machine learning and deep learning

SPEECH EMOTION CLASSIFICATION **(06 Hours)**

Effect of emotional state on speech signal, Pitch and formant analysis for different emotions, Significance of databases: acted, evoked and natural, Emotion impacted feature extraction, feature selection, Machine learning and deep learning based emotion classification.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. L. R. Rabiner and R. W. Schafer, "Digital Processing of Speech Signals", 1st Ed., Pearson Education India, 2003.
2. J. Benetsy, M. M. Sondhi and Y. Huang, "Springer Handbook of Speech Processing", 1st Ed., Springer Verlag, 2008.
3. J. R. Deller, Jr., J. H. L. Hansen and J. G. Proakis "Discrete-Time Processing of Speech Signals", Wiley- IEEE Press, IEEE Edition, NY, USA, 1999.
4. D. O'Shaughnessy, "Speech Communications: Human and Machine", 2nd Ed., University Press, 2005.
5. Thomas F Quatieri, "Discrete-Time Speech Signal Processing – Principles and Practice", 1st Ed., Pearson Education, 2006.
6. Gold, B., Morgan, N., & Ellis, D., "Speech and audio signal processing: processing and perception of speech and music" John Wiley & Sons, 2011.

M.Tech. I (Communication systems) Semester – II

Real Time Systems

L	T	P	Credit
3	0	0	03

ECVL104 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe the foundation for programming languages developed for real time programming.
CO2	Apply real time operating systems and their functions.
CO3	Analyze the real time network.
CO4	Evaluate the real time systems with regard to keeping time and resource restrictions.
CO5	Design real time applications with RTOS.

2. Syllabus:

INTRODUCTION TO REAL-TIME SYSTEMS (09 Hours)

Hard versus Soft Real Time Systems, Reference Models of Real Time Systems, Operating System Services, I/O Subsystems, Network Operations Systems, Real Time Embedded Systems, Operating Systems Interrupt Routines in RTOS Environments, RTOS Task Scheduling Models, Interrupt Latency and Response Time, Standardization Of RTOS

REAL-TIME SCHEDULING AND SCHEDULABILITY ANALYSIS (10 Hours)

Task, Process and Threads, Commonly Used Approaches To Real Time Scheduling, Clock-Driven Scheduling, Priority Driven Scheduling Of Periodic Tasks, Hybrid Scheduler, Event Driven Schedules.

Earliest Dead Line First (EDF) Scheduling, Rate Monotonic Algorithm (RMA), Real Time Embedded Operating Systems: Standard & Perspective, Real Time Operating Systems: Scheduling Resource Management Aspects, Quasi-Static Determining Bounds On Execution Times

RESOURCE SHARING AMONG REAL-TIME TASKS (12 Hours)

Data Sharing by Multiple Tasks And Routines Inter Process Communication, Handling Resources Sharing and Dependencies Among Real-time Tasks, Resource Sharing Among real Time tasks, Priority Inversion, Priority Inheritance Protocol (PIP), Highest Locker Protocol (HLP), Priority Ceiling Protocol (PCP), Different Types of Priority Inversion Under PCP, Important Features of PCP, Handling Task Dependencies,

DISTRIBUTED REAL-TIME SYSTEMS, MULTIPROCESSOR REAL-TIME SYSTEMS (07 Hours)

Multiprocessor and Distributed system, Partitioned scheduling, Global scheduling, Semi-partitioned scheduling, Distributed scheduling, Load balancing

REAL TIME COMMUNICATION AND DATABASE (07 Hours)

Real time traffic, Real-time data link layer, Protocols: CAN, Time-triggered protocol (TTP), Real-time ethernet, Real-time IEEE 802.11, Mobile Wireless Sensor Network

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Rajib Mall, “Real Time Systems Theory and Practice”, 1st Ed., Pearson Education, 2007.
2. Brian Amos, “Hands-On RTOS with Microcontrollers: Building real-time embedded systems using FreeRTOS, STM32 MCUs, and SEGGER debug tools”, 1 st Edition, Packt Publishing, 2020.
3. K. Erciyes, “Distributed Real-Time Systems-Theory and Practice”, Springer Cham, 1 st Edition, 2019.
4. Liu Jane, “Real-time Systems”, 1st Ed., Pearson Education India, 2006.
5. Xiaocong Fan, “Real-Time Embedded System-Design Principles and Engineering Practices”. 1st Edition, Newnes, 2015

M.Tech. I (Communication systems) Semester – II

VLSI Architecture For DSP

L	T	P	Credit
3	0	0	03

ECVL114 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe DSP algorithms using data flow graphs and various VLSI architectures for signal processing.
CO2	Apply fast convolution methods for optimization.
CO3	Analyze critical path algorithm and strength reduction.
CO4	Evaluate signal processing architectures based on area and power.
CO5	Design VLSI architectures for the signal processing based on specifications.

2. Syllabus:

DSP CONCEPTS **(10 Hours)**

Linear system theory, DFT, FFT, DCT realization of digital filters. Typical DSP algorithms, DSP applications, Data flow graph presentation of DSP algorithm.

ARCHITECTURAL ISSUES **(13 Hours)**

Binary Adders, Binary multipliers, Multiply Accumulator (MAC) and Sum of Product (SOP). Pipelining and Parallel Processing, Retiming, Unfolding, Folding, Register Minimization Technique and Systolic architecture design, Coordic Architecture, Distributed Arithmetic Architecture.

FAST CONVOLUTION **(11 Hours)**

Cook-Toom algorithm modified Cook-Toom algorithm, Winograd algorithm, modified Winograd algorithm, Algorithmic strength reduction in filters and transforms, DCT and inverse DCT, parallel FIR filters.

POWER ANALYSIS IN DSP SYSTEMS **(11 Hours)**

Multiprocessor and Distributed system, Partitioned scheduling, Global scheduling, Semi-partitioned scheduling, Distributed scheduling, Load balancing

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Keshap K. Parhi, “VLSI Digital Signal Processing Systems, Design and Implementation”, 1st Ed., John Wiley, 2007.
2. Keshab K. Parhi and Takao Nishitani, Marcel Dekker “Digital Signal Processing for Multimedia Systems”, 1st Ed., CRC Press, 1999.
3. U. Meyer-Baese, “Digital Signal processing with Field Programmable Arrays”, 3rd Ed., Springer, 2007.

4. V. K. Madisetti, “VLSI Digital Signal Processors: An Introduction to Rapid Prototyping and Design Synthesis”, IEEE Press, New York, 1995.
5. S. Y. Kung, H. J. Whitehouse, “VLSI and Modern Signal Processing”, 1st Ed., Prentice Hall, 1985.

M.Tech. I (Communication systems) Semester – III

Dissertation Phase-I

L	T	P	Credit
0	0	28	14

ECCS201 **Scheme**

1. **Course Outcomes (COs):**

At the end of the students will be able to:

CO1	Identify any latest topic of interest from the real-world technical problems to develop a thought process for design solution with basic understanding.
CO2	Extract a detailed literature survey related to the given problem and Apply the concepts for the solution to the given problem in terms of specifications, design, component selection etc.
CO3	Synthesize or Implement the model/prototype of the work.
CO4	Write the well organised report with compiled results and comprehension with proficiency in English.
CO5	Develop the effective and innovative presentation using modern tools/software.

(Total Contact Time: 560 Hours)

M.Tech. I (Communication systems) Semester – IV

Dissertation Phase-II

L	T	P	Credit
0	0	40	20

ECCS202 **Scheme**

1. **Course Outcomes (COs):**

At the end of the students will be able to:

CO1	Analyze and implement the proposed work.
CO2	Compare the existing techniques/methods with proposed work.
CO3	Evaluate the results in terms of the performance parameters and further optimize the work for better solution.
CO4	Write the well organised report with implemented results and comprehension with proficiency in English.
CO5	Attain the skills to solve real world problem in relevant area

(Total Contact Time: 800 Hours)

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SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY SURAT

VISION

To be one of the leading Technical Institutes disseminating globally acceptable education, effective industrial training and relevant research output.

MISSION

To be a globally accepted centre of excellence in technical education catalyzing absorption, innovation, diffusion and transfer of high technologies resulting in enhanced quality for all the stakeholders.

DEPARTMENT OF ELECTRONICS ENGINEERING

MISSION

The mission of the Department of Electronics Engineering is to contribute to society and industry through excellence in education, research, innovations, and ethics by stakeholders.

VISION

The vision of the Department of Electronics Engineering is to aim to achieve quality in education and research to create leading Electronics engineers, researchers, and entrepreneurs.

DEPARTMENT OF ELECTRONICS ENGINEERING

SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY

ICHCHHANATH, SURAT-395 007

M. Tech. Programme VLSI DESIGN AND EMBEDDED SYSTEMS

Programme Educational Objectives (PEOs):

Sr. No.	PEO Description
PEO-1	To prepare quality Postgraduates in Electronics Engineering with specialization in VLSI and Embedded System design with in-depth knowledge of relevant subjects.
PEO-2	To create professionals who can formulate, analyze, synthesize and be able to pursue higher research for engineering problems.
PEO-3	To develop skilful manpower in the area of VLSI and Embedded Systems who can design and manufacture state-of-the art systems/products to meet the requirements of industry.
PEO-4	To disseminate skills and experiences to the society by becoming an entrepreneur or leader.

Programme Outcomes (POs):

Sr. No.	PO Statement
PO-1.	Postgraduates will be able to identify research gaps through literature survey, apply appropriate research methodologies to propose solutions, conduct experiments and validate results through realistic scenarios and constraints.
PO-2.	Postgraduates will be able to communicate effectively in both oral and written context in the form of technical papers, thesis reports, design documents and seminar presentations.
PO-3.	Postgraduates will be able to demonstrate expertise in VLSI and Embedded System Design by prototype/product development.
PO-4.	Postgraduates will apply knowledge acquired in Mathematics, Science and Engineering to solve VLSI and Embedded System Design problems.
PO-5.	Postgraduates will be able to analyze complex engineering problems critically, apply reasoning for synthesis to make creative advances for conducting research.
PO-6.	Postgraduates will learn and use the latest hardware and software tools/platforms, modern techniques and technologies, optimization methods to solve complex engineering problems.

M. Tech. I (EC), I Semester (VLSI & Embedded Systems)											
Sr. No.	**Course Name**	**Code**	**Teaching Scheme**			**Credit**	**Examination Scheme**			**Total**	**Notional hours of Learning (Approx)**
			L	**T**	**P**		**Theory**	**Tutorial**	**Practical**		
1	DIGITAL VLSI DESIGN	ECVL101	3	0	0	3	100	--	--	100	55
2	MOS DEVICES AND TECHNOLOGY	ECVL103	3	0	0	3	100	--	--	100	55
3	EMBEDDED SYSTEMS	ECVL105	3	0	0	3	100	--	--	100	55
4	Elective I	ECVL1XX	3	0	0	3	100	--	--	100	55
5	Elective II	ECVL1XX	3	0	0	3	100	--	--	100	55
6	VLSI LAB-I	ECVL107	0	0	6	3	--	--	150	150	100
7	Seminar	ECVL109	0	0	4	2	--	--	100	100	70
Total			15	0	10	20	500	--	250	750	442
Total Contact Hours per week: 25											

M.Tech. I (EC), II Semester (VLSI & Embedded Systems)											
Sr. No.	**Course Name**	**Code**	**Teaching Scheme**			**Credit**	**Examination Scheme**			**Total**	**Notional hours of Learning (Approx)**
			L	**T**	**P**		**Theory**	**Tutorial**	**Practical**		
1	ANALOG VLSI DESIGN	ECVL102	3	0	0	3	100	--	--	100	55
2	REAL-TIME SYSTEMS	ECVL104	3	0	0	3	100	--	--	100	55
3	Elective III – Institute	ECVL1XX	3	0	0	3	100	--	--	100	55
4	Elective IV	ECVL1XX	3	0	0	3	100	--	--	100	55
5	Elective V	ECVL1XX	3	0	0	3	100	--	--	100	55
6	VLSI LAB-II	ECVL106	0	0	6	3	--	--	150	150	100
7	Minor Project	ECVL108	-	-	4	2	--	--	100	100	70
Total			15	0	10	20	500	--	250	750	442
Total Contact Hours per week: 25											

M.Tech. II (EC), III Semester (VLSI & Embedded Systems)											
Sr. No.	**Course Name**	**Code**	**Teaching Scheme**			**Credit**	**Examination Scheme**			**Total**	**Notional hours of Learning (Approx)**
			L	**T**	**P**		**Theory**	**Tutorial**	**Practical**		
1	Dissertation – Phase I	ECVL201	0	0	28	14	0	0	350	350	560
2	MOOC-I*	φ	-	-	-	3/4	100	-	-	-	70/80
3	MOOC-II*	φ	-	-	-	3/4	100	-	-	-	70/80
Total			0	0	-	20/21/22	200	0	350	350	700/720
Total Contact Hours per week: 28+ NPTEL x2											

*NPTEL, SWAYAM and other Massive Open Online Course (MOOC) approved by DAAC

φ : As per 66th IAAC, Dated 20th March, 2024, Resolution No. 66.34 and 61st Senate resolution No. 4, 25th April, 2024

M.Tech. II (EC), IV Semester (VLSI & Embedded Systems)											
Sr. No.	**Course Name**	**Code**	**Teaching Scheme**			**Credit**	**Examination Scheme**			**Total**	**Notional hours of Learning (Approx)**
			L	**T**	**P**		**Theory**	**Tutorial**	**Practical**		
1	Dissertation – Phase II	ECVL202	0	0	40	20	0	0	600	600	800
Total			0	0	40	20	0	0	600	600	800
Total Contact Hours per week: 40											

LIST OF SUBJECTS FOR ELECTIVE I & II (For 1st Semester):		
1.	Semiconductor IC Technology	ECVL111
2.	Hardware Description Language	ECVL113
3.	Processor Architecture	ECVL115
4.	Testing and Verification of VLSI Circuits	ECVL117
5.	Nanoelectronics	ECVL119
6.	Advanced Material Characterization Techniques	ECVL123
7.	Advance DSP	ECCS105
8.	Information Theory & Coding	ECCS111
9.	Machine Learning and its Applications	ECCS121

Elective-III Institute Elective (2nd Semester):		
1.	Solar Photovoltaic Technology	ECVL170
2.	MEMS	ECVL172
3.	Foundations of VLSI CAD	ECVL174
4.	Semiconductor Device Modelling	ECVL176

LIST OF SUBJECTS FOR ELECTIVE IV & V (2nd Semester)		
1.	Low Power VLSI Design	ECVL112
2.	VLSI Architectures for DSP	ECVL114
3.	VLSI System Design	ECVL116
4.	SOC Design	ECVL118
5.	CMOS RF IC Design	ECVL120
6.	Nanoscale Devices	ECVL122
7.	Semiconductor Packaging	ECVL124
8.	Neuromorphic Computing	ECVL126
9.	Mixed Signal IC Design	ECVL128
10.	Memory Technology	ECVL130
11.	High-Speed Interconnect	ECVL132
12.	Image Processing & Computer Vision	ECCS102
13.	Wireless Communication	ECCS104
14.	Microwave Integrated Circuits	ECCS116
15.	Speech Processing and Applications	ECCS130

M.Tech. I (VL/CS) Semester – I DIGITAL VLSI DESIGN ECVL101	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Understand VLSI design flow and CMOS inverter
CO2	Implement CMOS combinational and Sequential logic
CO3	Analyze circuit characteristic
CO4	Evaluate circuit performance
CO5	Design digital subsystems

2. Syllabus

INTRODUCTION TO VLSI DESIGN (04 Hours)

Historical Perspective, Design Hierarchy, Concepts Of Regularity, Modularity And Locality, VLSI Design Challenges, Introduction of VLSI Design Flow:, From Custom to Semi Custom and Structured Array Design Approaches, Custom Circuit Design, Cell-Based Design Methodology: Standard Cell, Compiled Cells, Macrocells, Megacells and Intellectual Property, Semi-Custom Design Flow; Array-Based Implementation Approaches: Pre-Diffused (or Mask-Programmable) Arrays, Pre-Wired Arrays.

CMOS INVERTER BASICS and COMBINATIONAL LOGIC CIRCUIT (09 Hours)

Brief introduction to MOS transistor models and SPICE parameters; process parameters and design rules
Introduction, The Static CMOS Inverter — An Intuitive Perspective, Evaluating the Robustness of the CMOS Inverter (The Static Behavior): Switching Threshold, Noise Margins, Robustness Revisited; Performance of CMOS Inverter (The Dynamic Behavior): Computing the Capacitances, Propagation; Delay: First-Order Analysis, Propagation Delay from a Design Perspective; Power, Energy and Energy- Delay: Dynamic Power Consumption, Static Consumption, Perspective: Technology Scaling and its Impact on the Inverter Metrics
CMOS Combinational Logic Circuits, Complex Logic Circuits, Layout Techniques, Behavior Of MOS Logic Elements, CMOS Pass Gate and Transmission Gate, Design of combinational circuit using pseudo-nMOS and DCVSL and DSL logic gates. CPL, DPTL and swing restored pass transistor logic styles

SEQUENTIAL LOGIC CIRCUIT (08 Hours)

Timing Metrics for Sequential Circuits, Classification of Memory Elements; Static Latches and Registers: The Bistability Principle, Multiplexer-Based Latches, Master-Slave Edge-Triggered Register, Low-Voltage Static Latches, Static SR Flip-Flops—Writing Data by Pure Force; Dynamic Latches and Registers: Dynamic Transmission-Gate Edge-triggered Registers, C2MOS—A Clock-Skew Insensitive Approach, True Single-Phase Clocked Register (TSPCR); Alternative Register Styles: Pulse Registers, Sense-Amplifier Based Registers; Pipelining (An approach to optimize sequential circuits): Latch- vs. Register-Based Pipelines, NORA-CMOS—A Logic Style for Pipelined Structures; Non-Bistable

Sequential Circuits: The Schmitt Trigger, Monostable Sequential Circuits, Astable Circuits; Perspective: Choosing a Clocking Strategy

DYNAMIC LOGIC CIRCUIT **(05 Hours)**

Dynamic Logic (Basic Principles), Speed and Power Dissipation of Dynamic Logic, logic styles including np, Domino, NORA and TSPC logic, Issues in Dynamic logic due to charge sharing and race conditions, Cascading Dynamic Gates; Perspectives: How to Choose a Logic Style

CIRCUIT CHARACTERIZATION, PERFORMANCE ESTIMATION AND TESTING **(06 Hours)**

Interconnect, Estimation of Interconnect Parasitic, Delay Estimation, Logical Efforts And Transistor Sizing, Power Dissipation, Design Margin, Reliability, Testing: Introduction, Automatic Test pattern Generation (ATPG), Design for Test (DFT), Buit-in self Test (BIST)

DIGITAL SUBSYSTEM DESIGN **(13 Hours)**

Design of IO buffers and on chip load drivers; PLL, clock generation and clock buffering; design of memory cells and sense amplifiers
Design of adders - Ripple carry, Manchester carry, carry look ahead, carry select and carry save
Design of multipliers (for unsigned and signed) - sequential, parallel, carry save, Booth multipliers; Wallace tree structures
Design of shifters and floating point arithmetic units

Total Contact Time: = 45 Hours

3. Books Recommended

1. Rabaey Jan M., Chandrakasan Anantha and Borivoje Nikolic, "Digital Integrated Circuits (Design Perspective)", 2nd Ed., Prentice Hall of India, 2016 (Reprint).
2. Kang and Leblebici,“CMOS Digital Integrated Circuits: Analysis and Design”, Tata McGraw-Hill, 4th Edition, 2019
3. Baker R. Jacob, Li H. W. & Boyce D. E.,“CMOS Circuit Design, Layout And Simulation”, Wiley, 4th Edition, 2009
4. Weste and Harris,“CMOS VLSI Design: A Circuits and Systems Perspective”, Pearson Education, 4th Edition, 2020
5. Pucknell and Eshraghian: “Basic VLSI Design”, Prentice Hall of India, 3rd Edition, 2003

M.Tech. I (VL/CS) Semester – I MOS DEVICES AND TECHNOLOGY ECVL103	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Understanding and analysis of semiconductor Physics and PN Junction
CO2	Understanding of MOS capacitor and MOSFET
CO3	Derivation of I-V and C-V of MOSFET and MOS Capacitor respectively
CO4	Evaluation of advanced electronic devices
CO5	Design of MOSFET and MOS Capacitor

2. Syllabus

PHYSICS OF SEMICONDUCTOR AND PN JUNCTION (15 Hours)

Allowed and Forbidden Bands, Band Structure, Density of States Function, Statistical Mechanics, Electrical Conduction Semiconductor In Equilibrium, Carrier Transport Phenomena, Non-Equilibrium Excess Carries in Semiconductor, PN Junction Current, Small Signal Model, Generation And Recombination Current, Junction Break Down

MOS CAPACITOR and MOSFET (15 Hours)

Metal Semiconductor and Hetero Junctions, Two Terminal MOS Structure, CV Characteristics, MOSFET Operation, I-V derivation, Frequency Limitation, Short channel effects, MOSFET scaling, Radiation, and hot electron effect

LARGE SIGNAL AND LOW-FREQUENCY SMALL SIGNAL MODELING (10 Hours)

Quasi-Static modeling and Non quasi static modeling of MOSFET, Transit time, Equivalent model of MOSFET with extrinsic resistance and capacitance, low frequency small signal modeling for weak, moderate and strong region of operation.

ADVANCE MOS DEVICES (05 Hours)

Introduction of advanced devices FDSOI, FinFET, Tunnel FET, Nanosheet device, HEMT

Total Contact Time: = 45 Hours

3. Books Recommended

1. Donald Neaman,“Semiconductor Physics and Devices”,McGraw Hill, 4th Edition, 2012
2. Sze S. M.,“Semiconductor Devices, Physics And Technology”,John Wiley and Son s 3rd Edition, 2007
3. Sze S. M.,“Physics of Semiconductor Devices”, John Willey 3rd Edition, 2007
4. Streetman,“Solid State Electronics Device”, HI, 2005
5. Yannis Tsividis, Colin McAndrew, “Operation And Modeling Of The Mos Transistor”, Oxfor university press, 3rd Edition, 2012
6. Taur and Ning, “Fundamentals of Modern VLSI Devices” Cambridge University Press, 2021.
7. M. S Lundstrom and J. Guo,“Nanoscale Transistors: Device Physics, Modeling and Simulation” Springer, 2006
8. D Esseni P Palestri and L Selmi,“Nanoscale MOS Transistors: Semi-Classical Transport and Applications”, Cambridge University Press, 2011.

Additional Resources:

1. M. Alam, "ECE 695A Reliability Physics of Nanotransistors," https://nanohub.org/resources/16560.
2. M. Lundstrom, "ECE 612: Nanoscale Transistors (Fall 2008)," https://nanohub.org/resources/5328.
3. Mark Lundstrom (2008), "Physics of Nanoscale MOSFETs," https://nanohub.org/resources/5306.

Relevant Journals and Conference papers.

M.Tech. I (VL/CS) Semester – I EMBEDDED SYSTEMS ECVL105	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Understand Embedded systems and describe CPU architectures and variety of microcontrollers
CO2	Demonstrates CPU processor, its modes, exception handling, instruction pipelining and basic programming
CO3	Implementation with Assembly and C language programming for ARM Cortex-M.
CO4	Analyze 32-bit ARM microcontroller architecture, External Memory, Counters & Timers, Serial Data Input/Output and Interrupts. Design for interfacing Keys, LED/LCD Displays, ADC And DAC.
CO5	Design a typical cost-effective real-world embedded system with appropriate hardware/software components and embedded OS

2. Syllabus

INTRODUCTION TO EMBEDDED SYSTEMS (08 Hours)

Overview and Characteristics of Embedded Systems, Classification and Application Areas, Process of Embedded System Development, RISC Vs CISC CPU Architectures, 8/16/32 bit Microcontrollers Family, Components in embedded system development environment (IDE)

ARM CORTEX M3/M4 ARCHITECTURE (10 Hours)

Overview of ARM Cortex family, Operation modes and states, Registers, Special Registers, Floating point Registers, Memory system and MPU, Exception and interrupts, System control block, OS Support features, ARM Instruction Set Architecture, Arithmetic and Logic, Load and Store, Branch and Conditional Execution

PROGRAMMING CORTEX M3/M4 IN ASSEMBLY and C (10 Hours)

Structured Programming, Subroutines, 64-bit Data Processing, Mixing C and Assembly, Interrupt and NVIC, Fixed-point and Floating-point Arithmetic, Writing optimized ARM assembly/C code, Exception and fault handling routines

USING EMBEDDED OS (08 Hours)

Introduction to Embedded OS, Task and Threads, Creation of Threads, Inter-thread communications, Signal event, Semaphores, Message queue, OS based programming examples.

PERIPHERAL INTERFACING (09 Hours)

General-purpose I/O, General-purpose Timers, Real-time Clock (RTC), Direct Memory Access (DMA), Analog-to-Digital Converter (ADC), Digital-to-Analog Converter (DAC), Serial Communication interface such as UART, I2C, SPI, Ethernet, CAN etc

Total Contact Time: 45 Hours

3. Books Recommended

1. Joseph Yiu, “A definitive guide to the ARM-Cortex M3 and Cortex-M4 Processors”, 3rd Ed., Newnes, 2013
2. A.N.Sloss, D.Symes and C. Wright, “ARM System Developer’s Guide: Designing and Optimizing System Software”, Elsevier, 2004
3. Y. Zhu, “Embedded Systems with Arm Cortex-M3 Microcontrollers in Assembly Language and C”, E-Man Press LLC, 2014
4. Wayne Wolf, “Computers as Components: Principles of Embedded Computing System Design (The Morgan Kaufmann Series in Computer Architecture and Design)”, 2nd Edition, 2008
5. Prasad K. V. K. K., “Embedded / Real-Time Systems: Concepts, Design And Programming”, DreamTech Press, 2005

M.Tech. I (VL/CS) Semester – I SEMICONDUCTOR IC TECHNOLOGY ECVL111	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Understand material processing techniques and Pattern Transfer process
CO2	Demonstrates the concept behind thin film deposition, and characterization techniques.
CO3	Compare metal contact formation, interconnect, bonding and packaging.
CO4	Evaluate different fabrication, characterization, and metallization techniques.
CO5	Design basic semiconductor devices and their characterization.

2. Syllabus

INTRODUCTION TO MICROELECTRONIC FABRICATION AND MATERIALS (08 Hours)

Semiconductor substrate: Crystal structure, Crystal defects, Crystal growth, Wafer fabrication and basic properties of Silicon Wafers, Wafer cleaning, and native oxide removal, Substrates beyond Silicon, Surface reactions, Dopants, Defects in epitaxial growth, Clean Room, and Safety requirements. Diffusion, Thermal Oxidation, Ion implantation, Etching.

MASK FABRICATION AND ADVANCED LITHOGRAPHY TECHNIQUES (05 Hours)

Overview, Optical lithography, Photoresist, Mask Development, Patterning Strategies, Electron beam lithography process, EUV Lithography, X-ray lithography, and Other advanced lithography systems

THIN-FILM TECHNOLOGIES (09 Hours)

Physical Vapor Deposition: Evaporation Systems, Sputtering systems, and state-of-art Systems
Chemical Vapor Deposition: CVD system, Advanced CVD systems: LPCVD, UHCVD, AACVD, and advanced systems
Epitaxial Deposition: MOCVD, MBE, and CBE.
Solution-Based Deposition Techniques: Electrodeposition, Spin Casting, Printing, Layer-by-Layer Deposition, Colloidal Synthesis.

MEMS FABRICATION TECHNIQUES (05 Hours)

Silicon Pressure Sensors, Micro-Electro-Mechanical Systems, Micromachining Techniques, Isotropic Etching and Anisotropic Etching, Wafer Bonding, and LIGA Processes.

NANOSCALE DEVICE CHARACTERIZATION TECHNIQUES (09 Hours)

X-ray diffraction, X-ray photoelectron Spectroscopy, Spectroscopic Ellipsometry, Field Emission Scanning Electron Microscope, Transmission Electron Microscope, Atomic Force Microscope, Raman Spectroscopy, UV-Vis Measurement, Photo-Luminescence, Hall Measurement, Capacitance Voltage Measurement and Current-voltage measurement.

PROCESS INTEGRATION **(04 Hours)**

Contacts and metallization: Junction and oxide isolation, Si on insulator, Schottky and Ohmic contacts, Multilevel metallization.
CMOS technologies: Device behavior, Basic 3 µm technologies, Device scaling.
Circuit Manufacturing: Yield, Particle control, Design of experiments, computer-integrated manufacturing.

INTERCONNECTS, BONDING, AND PACKAGING: **(05 Hours)**

Metallization, Silicides, CVD Tungsten Plug Process, Gold Wire Bonding and Other Bonding Technologies, Package Types, Assembly Techniques, Package Fabrication Technology, Package Design Considerations.

(Total Contact Hours: 45)

3. Books Recommended

1. Stephen A. Campbell, “The Science and Engineering of Microelectronic Fabrication”, 2nd edition Oxford University Press, 2006.
2. S.M. Sze (Ed), “VLSI Technology”, McGraw Hill, 1998.
3. Hrundle, Evans, Wilson, “Encyclopedia of Material Characterization”, Elsevier, 2005
4. D. K. Schroder, “Semiconductor Material and Device Characterization”, Wiley, 3rd edition, 2006
5. James Plummer, M. Deal and P.Griffin, “Silicon VLSI Technology”, Prentice Hall, 2016.
6. Rebeiz, G.M., RF MEMS: Theory Design and Technology, Wiley, 2004
7. Stephen A. Campbell, “Fabrication engineering at the Mocto- and NanoScale”, 4th edition Oxford University Press, 2013.

Additional Resources

1. Relevant Journals and Conference publications.

M.Tech. I (VL/CS) Semester – I HARDWARE DESCRIPTION LANGUAGE ECVL113	Scheme	L	T	P	Credit
		3	0	0	03

1.	Course Outcomes (COs): At the end of the course, the students will be able to
CO1	Understand the concept of structural, data flow and behavioral style of hardware description and model various delays
CO2	Implement register transfer and gate level Digital system circuits. Also, verify with HDL simulations, Sequential circuits and FSMs
CO3	Develop and implement combinational logic circuits such as mux, demux, encoder, decoder, adders using Verilog and VHDL.
CO4	Evaluate the synthesized hardware for area, power and speed
CO5	Design ALU, instruction decoder, FIFO using HDL

2. Syllabus

INTRODUCTION **(11 Hours)**

Basic Concepts Of Hardware Description Languages, Hierarchy, Concurrency, Logic And Delay Modeling, Structural, Data-Flow And Behavioral Styles of Hardware Description, Architecture Of Event Driven Simulators

VHDL – Modelling and Analysis **(16 Hours)**

Syntax And Semantics Of VHDL, Variable And Signal Types, Arrays And Attributes, Operators, Expressions And Signal Assignments, Entities, Architecture Specification And Configurations, Component Instantiation, Concurrent And Sequential Constructs, Use Of Procedures And Functions, Examples of Digital Design Using VHDL

VERILOG – Digital Design and Synthesis **(18 Hours)**

Syntax And Semantics Of Verilog, Variable Types, Arrays And Tables, Operators, Expressions And Signal Assignments, Modules, Nets And Registers, Concurrent And Sequential Constructs, Tasks And Functions, Examples Of Design Using Verilog, Synthesis Of Logic From Hardware Description

(Total Contact Hours: 45)

3. Books Recommended

1. Bhaskar J.,“VHDL Primer”,Pearson Education Asia, 3rd Edition, 2015
2. Perry D.,“VHDL”,Tata McGraw-Hill, 4th Edition, 2017
3. Navabi Z.,“VHDL”,McGraw Hill, 3rd Edition,2007
4. Palnitkar S.,“Verilog HDL: A Guide to Digital Design and Synthesis”, Pearson, 2nd Edition, 2003
5. Bhaskar J.,“Verilog HDL Synthesis - A Practical Primer”,Star Galaxy Publishing, 2018

M.Tech. I (VL/CS) Semester – I PROCESSOR ARCHITECTURE ECVL115	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Discuss different processor architectures and system-level design processes.
CO2	Demonstrate the components and operation of a memory hierarchy and the range of performance issues influencing its design.
CO3	Analyze the organization and operation of current generation parallel computer systems, including multiprocessor and multicore systems.
CO4	Evaluate the principles of I/O in computer systems, including viable mechanisms for I/O and secondary storage organization.
CO5	Develop systems programming skills in the content of computer system design and organization.

2. Syllabus

COMPUTER ABSTRACTIONS AND TECHNOLOGY (04 Hours)

Technologies for building processors and memory, Performance, Power wall, the switch from uniprocessors to Multiprocessors.

INSTRUCTION SET ARCHITECTURE OF 64-BIT RISC-V (08 Hours)

RISC-V addressing modes, instruction types, logical operations, instructions for making decisions, supporting procedures, RISC-V addressing for Wide Immediate and addresses, parallelism and instructions, comparison with MIPS and x86 Architectures.

PIPELINING (11 Hours)

An overview of pipelining, pipelined data-path and control, Data hazards: Forwarding versus Control, Control hazards, Exceptions, Parallelism via instructions, Real stuff: ARM Cortex-A53 and Intel Core i7 Pipelines, Case study: ILP and matrix multiply.

PARALLEL PROCESSORS (13 Hours)

Parallel programs, Flynn’s taxonomy, Hardware multithreading, multicore and shared memory multiprocessors, Graphics processing units, Clusters and message passing multiprocessors, Multiprocessor networks, Benchmarking of Intel Core i7 960 and NVIDA Tesla GPU, Case study: Multiprocessors and matrix multiply, Cache coherence, Advanced Cache optimizations, Real stuff: The ARM Cortex-A53 and Intel Core i7 memory hierarchy, Case study: Cache blocking and matrix multiply.

STORAGE AND INTERCONNECTION (09 Hours)

The basic principles of interconnection network design, On-Chip Interconnection Network, Router Architecture, Network interface design, Case Study: NoC

(Total Contact Hours: 45)

3. Books Recommended

1. David A. Patterson, John L. Hennessy, “Computer Organization and Design: The Hardware Software Interface [RISC-V Edition]”, The Morgan Kaufmann Series in Computer Architecture and Design, 2017
2. John L Hennessy, “Computer architecture: a quantitative approach”, 6th Ed., Morgan Kaufmann Publishers, 2019
3. Leander Seidlitz, "RISC-V ISA Extension for Control Flow Integrity", Technische Universität München, 2019
4. Andrew Waterman, KrsteAsanović, The RISC-V Instruction Set Manual: Volume I: User-Level ISA, riscv.org, 2017
5. Andrew Waterman, KrsteAsanović, The RISC-V Instruction Set Manual: Volume II: Privileged Architecture, riscv.org, 2017

4. Reference Books

1. William James Dally, Brian Patrick Towles, “Principles and Practices of Interconnection Networks”, Morgan Kaufmann, Year: 2004

M.Tech. I (VL/CS) Semester – I TESTING AND VERIFICATION OF VLSI CIRCUITS ECVL117	Scheme	L	T	P	Credit
		3	0	0	03

1.	Course Outcomes (COs): At the end of the course, the students will be able to
CO1	Understand test patterns required to detect faults in a circuit
CO2	Demonstrate the testability of a circuit
CO3	Implement methods/techniques to improve the testability of digital circuits
CO4	Analyse Logic BIST circuits
CO5	Design the formal verification techniques

2. Syllabus

INTRODUCTION (08 Hours)

Scope Of Testing And Verification In VLSI Design Process, Issues In Test And Verification Of Complex Chips, Embedded Cores And SOCs

VLSI TESTING OF FAULT MODELS (20 Hours)

Fundamentals Of Automatic Test Pattern Generation, Design For Testability, Scan Design, Test Interface And Boundary Scan, System Testing and Test For SOC, Delay Fault Testing

Mu TESTING OF LOGIC AND MEMORIES (10 Hours)

Test Automation, Design Verification Techniques Based On Simulation, Analytical And Formal Approaches

VERIFICATION (07 Hours)

Functional Verification, Timing Verification, Formal Verification, Basics of Equivalence Checking And Model Checking, Hardware Emulation

(Total Contact Hours: 45)

3. Books Recommended

1. Bushnell M. and Agrawal V. D.,“Essentials Of Electronic Testing For Digital, Memory And Mixed-Signal VLSI Circuits”,Kluwer Academic Publishers,2013.
2. Abramovici M., Breuer M. A. and Friedman A. D.,“Digital Systems Testing And Testable Design”,IEEE Press,1990.
3. Erik Seligman, Tom Schubert and M V Achutha Kiran Kumar, “ Formal Verification An Essential Toolkit for Modern VLSI Design ”, Morgan Kaufmann Publisher, 2023
4. Rashinkar P., Paterson and Singh L.,“System-On-A-Chip Verification-Methodology And Techniques”,Kluwer Academic Publishers,2001.
5. Neil H. E. Weste and David Harris,“Principles Of CMOS VLSI Design”,Addison Wesley, 3rd Edition,2004

M.Tech. I (VL/CS) Semester – I NANOELECTRONICS ECVL119	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Define various carrier transport mechanisms, properties of semiconductor materials, and novel devices using mathematical equations.
CO2	Describe the physics needed for special classes of nanoelectronic devices and their applications.
CO3	Illustrate the working of various nanoelectronic devices.
CO4	Analyse various nanoelectronic devices.
CO5	Design novel devices, processes, and applications based on them.

2. Syllabus

FUNDAMENTALS OF NANOSCALE PHYSICS (12 Hours)

Top-Down and Bottom-Up Approach, Potential of Nanotechnology and Nanoelectronics, Classical Particles, Quantum Mechanics of Electrons, Free and Confined Electrons, Quantum Structures.

BAND THEORY OF SOLIDS (08 Hours)

Electrons in Periodic Potential, Kronig-Penney Model of Band Structure, Band Theory of Solids, Graphene and Carbon Nanotubes.

TUNNEL JUNCTION AND APPLICATIONS OF TUNNELING (07 Hours)

Tunnelling Through a Potential Barrier, Potential Energy Profiles for Material interfaces, Applications of Tunnelling: Field Emission, Gate-Oxide Tunnelling and Hot Electron Effects in MOSFETS, STM and Double Barrier Tunnelling, and The Resonant Tunnelling Diode.

COULOMB BLOCKADE AND THE SINGLE-ELECTRON TRANSISTOR (07 Hours)

Coulomb Blockade: Coulomb Blockade in a Nanoscale capacitor, Tunnel Junctions, Tunnel Junction Excited by a Current Source, and Coulomb Blockade in Quantum dot circuit, Single-Electron Transistor.

QUANTUM STRUCTURES (11 Hours)

Quantum Wells, Quantum Wires and Quantum Dots, Ballistic Transport and Spin Transport.

(Total Contact Hours: 45)

3. Books Recommended

1. Hanson G. W., “Fundamentals of Nanoelectronics”, 1st Ed., Pearson Education, 2009.
2. Rogers B., Adams J. and Pennathur S. , “Nanotechnology: Understanding Small Systems”, CRC Press, Tayler and Francis Group, Third Edition, 2014.
3. Mahalik N. P., “Micromanufacturing and Nanotechnology”, Springer, 2006.
4. Kohler M., and Fritzsche W. , “Nanotechnology: An Introduction To Nanostructuring Techniques”, 1st Edition, 2008.
5. Kittel C., “Introduction to Solid State Physics”, Wiley, Eighth Edition, 2005.

M.Tech. I (VL/CS) Semester – I ADVANCED MATERIAL CHARACTERIZATION TECHNIQUES ECVL123	Scheme	L	T	P	Credit
		3	0	0	03

1.	Course Outcomes (COs): At the end of the course, the students will be able to
CO1	Describe and analyze different techniques available for the structural characterization of various materials systems.
CO2	Demonstrate knowledge of optical and electron microscopic techniques (microstructure imaging) to characterize different materials.
CO3	Analyze the internal structure of the material systems with different advanced diffraction techniques.
CO4	Evaluate appropriate spectroscopic techniques to measure electronic transitions to estimate parameters like energy band gap, elemental concentration, etc.
CO5	Investigate different characterization techniques in materials research and applications

2. Syllabus

INTRODUCTION (05 Hours)

Materials Properties and Microstructures, Need of materials characterization and available techniques, Probing Mechanisms for Materials Analysis

OPTICAL MICROSCOPY (10 Hours)

Optical microscope - Basic principles and components, Different examination modes (Bright field illumination, Oblique illumination, Dark field illumination, Phase contrast, Polarised light, Hot stage, Interference techniques), Stereomicroscopy, Photo-microscopy, Colour metallography.

ELECTRON MICROSCOPY (10 Hours)

Interaction of electrons with solids, Scanning electron microscopy Transmission electron microscopy and specimen preparation techniques, Scanning transmission electron microscopy, Energy dispersive spectroscopy, Wavelength dispersive spectroscopy.

ADVANCED DIFFRACTION TECHNIQUES (08 Hours)

Fundamental crystallography, Generation and detection of X-rays, Diffraction of X-rays, X-ray diffraction techniques, Electron diffraction.

ADVANCED SPECTROSCOPIC TECHNIQUES (12 Hours)

Optical Spectroscopy: UV, visible, IR, and Raman spectroscopes
Electron spectroscopy: Importance of surface characterization techniques, Physical principles of XPS, Photoelectric effects, XPS, AES & SIMS, Instrumentation, XPS patterns, Spin orbital Splitting, Quantitative analysis, Chemical effect, Chemical shift, Auger electron generation, Chemical effect, Quantitative analysis, Depth profiling and Applications

(Total Contact Hours: 45)

3. Books Recommended

1. C. S. Kumar, M. M Singh, R. Krishna, “Advanced material characterization”, 1st Edition CRC Press, Taylor and Francis Group, 2023
2. Sam Zhang, Lin Li, and Ashok Kumar “Materials Characterization Techniques”,1st Edition, CRC Press, 2008
3. A. K. Tyagi, Mainak Roy, S. K. Kulshreshtha and S. Banerjee, “Advanced Techniques for Materials Characterization”, Materials Science Foundations (monograph series), Volumes 49 – 51, 2009
4. P. R. Khangaonkar, “Introduction To Materials Characterization”, 1st Edition, Penram Intl. Publishing (India) Pvt. Ltd, 2008
5. D. Briggs, J.T. Grant (eds.), “Surface analysis by Auger and X-ray photoelectron spectroscopy”, IM Publications and Surface Spectra Limited, Cromwell Press, Trowbridge, UK, 2003

M.Tech. I (VL/CS) Semester – I ADVANCE DSP ECCS105	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Define different type of signals and systems, and analyze different system characteristics therein
CO2	Describe the concept of FIR, IIR, linear prediction filter, power spectrum estimation
CO3	Solve the problem related to different filtering techniques and power spectrum estimation
CO4	Analyze different filtering techniques
CO5	Design different filtering techniques for different signal processing applications

2. Syllabus

REVIEW OF DISCRETE SIGNAL REPRESENTATION AND ANALYSIS (06 Hours)

Continuous and discrete time signals, noise signal, different type of signals, operations of signals: addition, subtraction, multiplication, scaling, magnification, decimation, interpolation, differentiation and integration, static and dynamic system, LTI system, DFT and FFT

TIME AND FREQUENCY-DOMAIN DESIGN TECHNIQUES FOR IIR AND FIR FILTERS (09 Hours)

FIR And IIR Filter Specifications, FIR Filter Design- Fourier series method and Frequency Sampling Method, Design Of IIR Digital Filters: Butterworth, Chebyshev And Elliptic Approximations, Low Pass, Band Pass, Band Stop And High Pass Filters, Bilinear Transformation Method

EFFECT OF FINITE REGISTERS LENGTH (04 Hours)

Number Representation, Quantization Error, Round-Off Error, Overflow Error, Limit Cycle, System Noise behaviour, Noise Filtering By LSI System, Noise in a Cascade Of 2nd Order Filter, Stability of Linear Filter

MULTIRATE SIGNAL PROCESSING (05 Hours)

General Rate-Changing System, Integer-Factor Interpolation and Decimation and Rational-Factor Rate Changing, Efficient Multirate Filter Structures, Over sampling D/As, Perfect-Reconstruction Filter Banks and Quadrature Mirror Filters.

OPTIMAL FILTERING OF RANDOM SIGNALS (08 Hours)

Innovations Representation of a Stationary Random Process, Prediction, linear prediction: forward and backward methods, Linear prediction based filter analysis, Prediction error, Levinson recursion method for solving Toeplitz system of equations, AR and ARMA Filter, MLE and MAP, LMS and RLS adaptive filters.

POWER SPECTRUM ESTIMATION/ANALYSIS **(06 Hours)**

Non-parametric method, Parametric method, periodogram, Eigen analysis for spectral Estimation.

APPLICATION OF DSP **(07 Hours)**

Speech signal processing: Time domain processing of speech, methods for extracting the parameters, Filter bank analysis of speech, radar signal processing, musical sound processing, recent applications.

(Total Contact Hours: 45)

3. Books Recommended

1. Salivahanan S, “Digital Signal Processing”, Fourth Edition, Tata McGraw-Hill, 2019.
2. Rabiner L. R. and Gold B., “Theory and Applications Of Digital Signal Processing”, First Edition, Prentice Hall, 1992.
3. Oppenheim A. V. and Schafer, “Discrete Time Signal Processing”, Pearson, Third edition, 2014.
4. Proakis John G. and Manolakis D.G., “Digital Signal Processing: Principle, Algorithms and Applications”, Fourth Edition, Pearson, 2006.
5. Kay, Steven M “Fundamentals of statistical signal processing”, Prentice Hall, 1998.
6. L. R. Rabiner and R. W. Schafer, Digital Processing of Speech Signals, Pearson Education India, First Edition, 2003.

4. Reference Books

1. Mitra Sanjit K.,“Digital Signal Processing - A computer Based Approach”, McGraw-Hill,2005

M.Tech. I (VL/CS) Semester – I INFORMATION THEORY AND CODING ECCS111	Scheme	L	T	P	Credit
		3	0	0	03

1.	Course Outcomes (COs): At the end of the course, the students will be able to
CO1	Understand the notion of information in a mathematically sound way.
CO2	Compare and analyze lossless data compression techniques with varying efficiencies as per problem requirements.
CO3	Calculate entropy, joint entropy, relative entropy, conditional entropy, and channel capacity of a system.
CO4	Design decoding strategies for block codes, linear codes, cyclic codes and BCH codes for detection and correction of errors.
CO5	Design convolutional Encoding and Decoding that meets design objectives like required protection for detection and correction of errors.

2. Syllabus

INFORMATION THEORY (06 Hours)

Introduction to Information Theory, Entropy, Properties of Entropy, Measures for Continuous, Random Variable, Relative Entropy, Conditional and Joint Entropy, Measure of Information, Average Information, Extension of Zero Memory Source.

SOURCE CODING (12 Hours)

Properties of Codes, Variable Length Codes, Uniquely Decodable Codes, Kraft's Inequality, Prefix Codes, Average Length of a Code, Shannon’s First Theorem, Shannon’s Encoding Algorithm, Shanon-Fano Codes, Huffman's Codes, Arithmetic Codes, Lempel Ziv, Run Length Code, Code Efficiency and Redundancy, Practical Application of Source Coding: JPEG Compression.

CHANNEL MODELS AND CHANNEL CAPACITY (08 Hours)

Discrete Communication Channels, Continuous Channels, Entropy Functions and Equivocation, Mutual Information, Channel Capacity, redundancy and efficiency of channels, Symmetric channels, Binary Symmetric Channel, Binary Erasure Channel, Noise-Free Channel, Cascaded channels, Binary asymmetric channel, Shannon theorem

BLOCK CODES AND LINEAR CODES (06 Hours)

Introduction to Galois Field, Single Parity Check Codes, Product Codes, Hamming Codes, Minimum Distance of Block Codes, Linear Block Codes, Generator Matrices, Parity Check Matrices, Encoder, Standard array and Syndrome decoding, Error Correction and Error Detection Capabilities.

CYCLIC and BCH CODES **(08 Hours)**

Introduction to Cyclic Codes, Generator Polynomial, Syndrome Polynomial and Matrix Representation, Fire Code, Golay Code, CRC Codes and Circuit Implementation of Cyclic Codes, Introduction to BCH Codes: Generator Polynomials, Multiple Error Correcting BCH Codes, Decoding of BCH Codes, Introduction to Reed Solomon (RS) Codes.

CONVOLUTION CODE **(05 Hours)**

Introduction to Convolutional Codes, Trellis Codes: Generator Polynomial Matrix and Encoding using Trellis, Vitrebi Decoding, Introduction to Turbo Codes, Introduction to Trellis Coded Modulation (TCM), Introduction to Space Time Block Codes (STBC).

(Total Contact Hours: 45)

3. Books Recommended

1. Ranjan Bose, "Information theory, coding and cryptography", Tata McGraw-Hill,2nd Edition,2008
2. T. M. Cover and J. A. Thomas, "Elements of Information Theory", 2nd Ed., John Wiley & Sons,
3. New Jersey, USA, 2006.
4. Salvatore Gravano,"Introduction to Error Control Codes", Oxford University Press,1st Edition,2007
5. Shu Lin and Daniel Costello, "Error Control Coding", 2nd Ed., by Pearson, 2004.
6. Todd K. Moon, "Error Correcting Coding", Wiley India Edition,2006

M.Tech. I (VL/CS) Semester – I MACHINE LEARNING AND ITS APPLICATIONS ECCS121	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Understand fundamentals of Machine Learning and classify machine learning algorithms into supervised and unsupervised.
CO2	Evaluate performance of different ML algorithms and select suitable algorithm for a given problem.
CO3	Analyze a given problem and determine which algorithm to use.
CO4	Solve problems using various machine learning techniques.
CO5	Design applications using various ML algorithms to solve real life problems.

2. Syllabus

INTRODUCTION TO MACHINE LEARNING AND PREREQUISITES (11 Hours)

Definition and history of machine learning, Types of Machine Learning: Supervised, Unsupervised, and Reinforcement Learning, Applications of Machine Learning, Essential mathematics for machine learning: linear algebra and probability theory, Bayesian learning, Naïve Bayes, Normal density and discriminant function.

SUPERVISED MACHINE LEARNING ALGORITHMS (13 Hours)

Regression: Linear regression, Multiple linear regression, Polynomial regression, Ridge regression, Lasso Regression. **Classification:** Perceptron criteria, Logistic Regression, Multi-class logistic regression (one-vs-all), K-nearest neighbours (KNN), Linear support vector machine (SVM), Kernel SVM, Linear Machine with hinge loss, Decision trees and random forests.

UNSUPERVISED MACHINE LEARNING ALGORITHMS (12 Hours)

Clustering: K-Means clustering, Fuzzy K-means clustering, Mean shift clustering, Hierarchical clustering, DBSCAN, Gaussian mixture model, Expectation Maximization Algorithm. **Dimensionality Reduction:** Dimensionality Problem, Principal component analysis (PCA), t-Distributed Stochastic Neighbour Embedding (t-SNE), Linear Discriminant Analysis (LDA). Anomaly Detection.

INTRODUCTION TO DEEP LEARNING (09 Hours)

Neural Networks: Biological Neurons vs. Artificial Neurons, Perceptron, Learning XOR, Multilayer perceptron (MLP), Feed forward neural networks, Activation Functions: Sigmoid, Tanh, ReLU, etc. **Training Neural Networks:** Forward and backward propagation, Gradient Descent, Optimization algorithms, Loss functions, Overfitting and Regularization (Dropout, Batch Normalization). **CONVOLUTIONAL NEURAL NETWORKS:** Convolution, Cross correlation, building blocks of CNN, MLP vs CNN, Popular CNN models, Vanishing and Exploding Gradient.

Total Contact Time = 45 Hours

3. Books Recommended

1. C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2nd Ed., 2011.
2. Kevin P. Murphy, Machine Learning: A Probabilistic Perspective, The MIT Press, 2012.
3. Ethem Alpaydin, Introduction to Machine Learning, The MIT Press, 4th Ed, 2020.
4. Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar, Foundations of Machine Learning, The MIT Press, 2nd Ed, 2018.
5. Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press, 2016.

M.Tech. I (VL/CS) Semester – I VLSI LAB – I ECVL107	Scheme	L	T	P	Credit
		0	0	6	03

1.	Course Outcomes (COs): At the end of the course, the students will be able to
CO1	Understand the Semiconductor Devices, IC Technology, Digital VLSI Design and HDL
CO2	Implement the Semiconductor Devices, IC Technology, Digital VLSI Design
CO3	Analyze the Semiconductor Devices, IC Technology, Digital VLSI Design
CO4	Evaluate the performance the Semiconductor Devices, IC Technology, Digital VLSI Design
CO5	Design the Digital VLSI circuits for the given parameter using circuit at circuit level and at RTL

Semiconductor IC Technology

Following is the list of experiments but not limited to:

1. Demonstration of processing steps involved in the cleaning of Silicon wafers.
2. Demonstration of different furnaces used in material processing such as Muffle Furnace, vacuum oven, etc.,
3. Demonstration of microfabrication processes like deposition (Thermal Evaporation, DC Sputtering, RF Sputtering, etc.), patterning, etc.
4. Demonstration of Chemical Deposition Process for the material growth (Chemical Vapor Deposition, Spin Coating, etc.)
5. Electrical properties estimation of the thin film materials using Four Probe Hall Effect measurement setup.
6. Demonstration of spectrometers (Raman Spectrometer, UV-Visible-NIR Spectrometer
7. Current-Voltage and Capacitance-Voltage characteristics measurement using semiconductor parameter analyzer for different semiconductor devices.
8. Design a semiconductor resistor and simulate it for its current voltage characteristics.

MOS Device Technology

1. Simulate p-n junction diodes, plot current-voltage characteristics under forward and reverse bias and extract key parameters.
2. Simulate MOS Capacitor, plot capacitance-voltage characteristics and extract the key parameters.
3. Simulate n-Channel MOSFET, plot transfer and output characteristics. Extract critical parameters i.e. V_T, g_m, r_d, subthreshold slope (SS), etc. Show structural analysis using electron density and energy band diagram.
4. Simulate p-channel MOSFET. Plot transfer and output characteristics. Extract critical parameters i.e. V_T, g_m, r_d, subthreshold slope (SS), etc. Show structural analysis using electron density and energy band diagram.
5. CMOS inverter design and layout for given static and dynamic specifications.
6. CMOS Combinational Logic gate design and layout for given static and dynamic specifications.

Digital VLSI Design

1. CMOS inverter design and layout for given static and dynamic specifications
2. CMOS Combinational Logic gate design and layout for given static and dynamic specifications
3. Pass transistor and Transmission gate based logic design and layout
4. CMOS latches and Flip Flop design and layout
5. Dynamic logic circuit design and layout
6. CMOS logic circuit design using logical efforts
7. Design and layout of memory cells and sense amplifiers
8. Design and layout of adders - Ripple carry, Manchester carry, carry look ahead, carry select and carry save using full custom flow and find the area-delay product and power-delay product.
9. Design and layout of multipliers - Array, carry save, Wallace tree structures using full custom flow and find the area-delay product and power-delay product.
10. Design and layout of shifters and floating point arithmetic units using full custom design and find the area-delay product and power-delay product.

Embedded Systems

1 Introduction to ARM Cortex M3/M4 evaluation board and Keil ARM – MDK development flow.

2 Write an program to flash simple LEDs (D0, D1, ... , D7) connected to Ports in various Patterns

3 Write code to show up/down BCD count on Multiplexed 7-segment LED display updated every second. Use two keys (up & down) to change direction of counting.

4 Write a program to display “Welcome to SVNIT” as welcome message on LCD interface.

5 Interface 4x4 keypad and Display pressed key on LCD.

6 Interface stepper motor and rotate it in clockwise and anti-clock wise direction.

7 Generate Sine wave/Triangle/Square wave using SPI based DAC and observe on CRO. Increase or Decrease frequency using Keys in decades

8 Using the internal PWM module of ARM microcontroller, generate PWM and vary its duty cycle to control DC motor.

9 Interface accelerometer and read the its output through I2C serial communication.

10 Illustrate use of CMSIS-RTOS functions for embedded programming.

11 Demonstrate the use of keil RTX real time operating system for toggling LED ON/OFF.

12 Demonstrate use of threads and semaphores using keil RTX RTOS

Embedded Systems

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HDL

1 Implement Behavioral, Data flow and structural Modeling

2 Realization of combinational and sequential design style

3 Realization of blocking and non blocking assignment statements

4 Realization of signal vs variable

5 Implementation of Testbench and debugging concept

6 Implementation of state machine

7 ALU design using state machine

8 Logic implementation on FPGA board

M.Tech. I (VL/CS) Semester – I Seminar ECVL109	Scheme	L	T	P	Credit
		0	0	4	02

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Understand any topic of interest and develop a thought process for technical presentation
CO2	Demonstrate a detailed literature survey and build a document with respect to technical publications.
CO3	Analyze the proof-of-concept and related data.
CO4	Evaluate the presentation skill.
CO5	Create technical reports

M.Tech. I (VL) Semester – II ANALOG VLSI DESIGN ECVL102	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Understand Impact of MOS Device Parameters on Analog Circuit Design and the Analog Design Requirements.
CO2	Design and Analyze various CMOS Amplifiers, Differential Amplifiers, Current Source/Sink Circuitry.
CO3	Analyze various Opamp topologies and compensation techniques.
CO4	Evaluate suitability of a specific topology of Analog Sub-Circuits / Biasing Circuits / Data Converters etc. for a particular application.
CO5	Investigate Switch Capacitor Circuits for filter design

2. Syllabus

ANALOG CMOS SUB-CIRCUITS (10 Hours)

Small Signal Model For MOS, MOS Switch, MOS Resistors, Current Sink/Source, High Input Impedance Current Mirrors, Differential, Cascode And Current Amplifiers, Output Amplifiers, High Gain Amplifier Architectures

CMOS OPERATIONAL AMPLIFIERS (09 Hours)

Design of CMOS Operational Amplifiers, Telescopic Op-amp topologies, Compensation, Design of Two Stage Op-Amps, Cascode Op-Amps, Simulation And Measurement Techniques

HIGH PERFORMACE CMOS OP-AMPS (07 Hours)

Buffered Op-Amps, High Speed/Frequency Op-Amps, Differential Output Op-Amps, Micro Power Op- Amps, Low Noise And Low Voltage Op-Amps

SWITCHED CAPACITOR FILTERS (09 Hours)

Switched Capacitor Circuits: Design and Analysis, Switched Capacitor Amplifiers, Switched Capacitor Integrators, Z Domain Models, 1st And 2nd Order Switch Capacitor Filters, Higher Order Filters

D/A AND A/D CONVERTERS (10 Hours)

Sample And Hold Circuits. Characterization of DAC, Nyquist Rate, Parallel DAC, Extending Resolution Of Parallel DAC, Serial DAC, Characterization Of ADC, Serial ADC, High Speed ADC, Over Sampling Techniques

Total Contact Time: 45 Hours

3. Books Recommended

1. John D.A. and Martin K.,“Analog Integrated Circuit Design”, 2nd Ed., Wiley, 2013
2. Razavi Behzad,“Design of Analog CMOS Integrated Circuit”,Tata McGraw-Hill, 2nd Edition, 2017
3. Allen Philip and Holberg Douglas,“CMOS Analog Circuit Design”,Oxford University Press, 3rd Edition, 2016
4. Gregorian R. and Temes G.C., “Analog MOS ICs for Signal Processing”, Wiley 2008
5. Baker Jacob R., Harry W. Li and Boyce David E.,“CMOS: Circuit Design, Layout and Simulation”,Wiley,Interscience, 3rd Edition, 2013

M.Tech. I (VL) Semester – II REAL TIME SYSTEMS ECVL104	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Describe the foundation for programming languages developed for real time programming.
CO2	Apply real time operating systems and their functions.
CO3	Analyze the real time network.
CO4	Evaluate the real time systems with regard to keeping time and resource restrictions.
CO5	Design real time applications with RTOS.

2. Syllabus

INTRODUCTION TO REAL-TIME SYSTEMS (09 Hours)

Hard versus Soft Real Time Systems, Reference Models of Real Time Systems, Operating System Services, I/O Subsystems, Network Operations Systems, Real Time Embedded Systems, Operating Systems Interrupt Routines in RTOS Environments, RTOS Task Scheduling Models, Interrupt Latency and Response Time, Standardization Of RTOS

REAL-TIME SCHEDULING AND SCHEDULABILITY ANALYSIS (10 Hours)

Task, Process and Threads, Commonly Used Approaches To Real Time Scheduling, Clock-Driven Scheduling, Priority Driven Scheduling Of Periodic Tasks, Hybrid Scheduler, Event Driven Schedules, Earliest Dead Line First (EDF) Scheduling, Rate Monotonic Algorithm (RMA), Real Time Embedded Operating Systems: Standard & Perspective, Real Time Operating Systems: Scheduling Resource Management Aspects, Quasi-Static Determining Bounds On Execution Times

RESOURCE SHARING AMONG REAL-TIME TASKS (12 Hours)

Data Sharing by Multiple Tasks And Routines Inter Process Communication, Handling Resources Sharing and Dependencies Among Real-time Tasks, Resource Sharing Among real Time tasks, Priority Inversion, Priority Inheritance Protocol (PIP), Highest Locker Protocol (HLP), Priority Ceiling Protocol (PCP), Different Types of Priority Inversion Under PCP, Important Features of PCP, Handling Task Dependencies,

DISTRIBUTED REAL-TIME SYSTEMS, MULTIPROCESSOR REAL-TIME SYSTEMS (07 Hours)

Multiprocessor and Distributed system, Partitioned scheduling, Global scheduling, Semi-partitioned scheduling, Distributed scheduling, Load balancing

REAL TIME COMMUNICATION AND DATABASE **(07 Hours)**

Real time traffic, Real-time data link layer, Protocols: CAN, Time-triggered protocol (TTP), Real-time ethernet, Real-time IEEE 802.11, Mobile Wireless Sensor Network

Total Contact Time: 45 Hours

3. Books Recommended

1. Rajib Mall, “Real Time Systems Theory and Practice”, 1st Ed., Pearson Education, 2007.
2. Brian Amos, “Hands-On RTOS with Microcontrollers: Building real-time embedded systems using FreeRTOS, STM32 MCUs, and SEGGER debug tools”, 1 st Edition, Packt Publishing, 2020
3. K. Erciyes, “Distributed Real-Time Systems-Theory and Practice”, Springer Cham, 1 st Edition, 2019
4. Liu Jane, “Real-time Systems”, 1 st Ed., Pearson Education, India, 2006.
5. Xiaocong Fan, “Real-Time Embedded Systems-Design Principles and Engineering Practices”, 1 st Edition, Newnes, 2015

M.Tech. I (VL) Semester – II SOLAR PHOTOVOLTAICS TECHNOLOGY ECVL170	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Explain Solar Resource and Basics of Photovoltaic Systems.
CO2	Describe requirements for the efficient Photovoltaic Device Design and Processing.
CO3	Demonstrate different solar cell fabrication and characterization techniques.
CO4	Analyze the Current and Emerging PV technologies, and PV Module related concepts.
CO5	Design the Solar Photovoltaic Devices.and PV Modules

2. Syllabus

INTRODUCTION TO SOLAR PHOTOVOLTAICS (03 Hours)

Solar Resource, Solar Energy Conversion Technologies, Need of Solar PV, Prospects of PV technology.

FUNDAMENTALS OF SOLAR CELLS (10 Hours)

Light Absorption, Charge Excitation, Charge Drift/Diffusion, Charge Separation, Charge Collection, PN junction diodes: Dark IV, illuminated IV, Device Performance parameters: Short Circuit Current, Open Circuit Voltage, Fill Factor, Efficiency, Series/ Shunt Resistance, Factors affecting the performance parameters, Detailed Balanced Limit.

FABRICATION AND CHARACTERIZATION OF SOLAR CELLS (10 Hours)

Solar Cell Fabrication:

Vacuum Based Deposition Techniques: Chemical Vapor Deposition (CVD), Physical Vapor Deposition (PVD): Sputtering, Electron Beam Evaporation, Pulsed Laser Deposition, Atomic Layer Deposition, Molecular Beam Epitaxy.

Solution Based Deposition Techniques: Electrodeposition, Spin Coating, Layer-by Layer Deposition, Printing, Colloidal Synthesis.

Solar Cell Characterization:

Solar Simulator, Quantum Efficiency Measurement, Secondary Ion Mass Spectroscopy, XPS/UPS, FESEM, Energy Dispersive X-Ray Spectroscopy, Photo-Luminescence

COMMERCIAL AND EMERGING TECHNOLOGIES IN SOLAR CELLS (10 Hours)

Silicon PV Technology, Chalcopyrite/ Kesterite Solar Cells, Organic Photovoltaics, Dye Sensitized Solar Cells, Perovskite Solar cells, Transparent Photovoltaic Devices, Flexible PV Devices, Multijunction Devices, Concentrator Solar Cells.

CUTTING-EDGE THEMES AND PV MODULES **(07 Hours)**

Light manipulation in PV Devices: Plasmonic Integration, Surface Texturing, Spectrum Splitting Techniques.

Module Design, Interconnection effects, Temperature effects, Lifetime of PV modules, Module measurement.

PV DEVICE MODELING **(05 Hours)**

Basics of Solar Cell Device Modeling, Thin-Film Solar Cell Device Modeling: Hands-on with an Open Source Tool, Modeling of PV Modules.

(Total Contact Hours: 45)

3. Books Recommended

1. Martin A. Green, “Solar Cells: Operating Principles, Technology and System Applications”,, Prentice-Hall, 1986.
2. Jenny Nelson, “The Physics of Solar cells”, World Scientific, 2003.
3. Smets Arno et al., “Solar Energy Fundamentals, Technology, and Systems”, UIT Cambridge. 2013
4. D. K. Schroder, “Semiconductor Material and Device Characterization”, Wiley Interscience, 2006
5. Konrad Mertens, “Photovoltaics Fundamentals, Technology, and Practice”, Wiley, 2018,
6. J. Poortmans and V. Arkhipov, “Thin Film Solar Cells: Fabrication, Characterization and Applications”, Willey, 2006.

4. Reference Recommended

1. Antonio Luque, Steven Hegedus, “Handbook of Photovoltaic Science and Engineering”, Wiley, 2011
2. Relevant Journal and Conference publications.

M.Tech. I (VL/CS) Semester – II MEMS ECVL172	Scheme	L	T	P	Credit
		3	0	0	03

1.	Course Outcomes (COs): At the end of the course, the students will be able to
CO1	Understand the MEMS fabrication process and characterization
CO2	Describe MEMS Materials & their Properties for Device Applications
CO3	Interpret Elasticity in Materials
CO4	Analyze MEMS Capacitive Switch
CO5	Design MEMS devices for different application

2 Syllabus:

INTRODUCTION TO MICRO-FABRICATION: (09 Hours)

Cleaning, Oxidation, Diffusion, Mask making, Lithography, Etching, Ion Implantation, CVD, PVD, Metallization; Surface micromachining and Bulk Micromachining, DRIE, LIGA, Fabrication of high aspect ratio deformable structures, wafer bonding

UNDERSTANDING MEMS MATERIALS & THEIR PROPERTIES FOR DEVICE APPLICATIONS (06 Hours)

Materials (eg. Si, SiO2, SiN, Cr, Au, Ti, SU8, PMMA, Pt); Important properties: Young modulus, Poisson's ratio, density, piezoresistive coefficients, TCR, Thermal Conductivity, Material Structure. Understanding Selection of materials based on applications

ELASTICITY IN MATERIALS (06 Hours)

Stress, strain calculations, Normal and Shear strains and constitutive relations, Plane stress, biaxial stress, residual stress, energy relations, Load-deflection calculations in beams, cantilevers (rectangular cross section), Elastic deformation in square plate, Resonant frequency calculations: Rayleigh-Ritz method

MEMS CAPACITIVE SWITCH (12 Hours)

Lumped model, pull-in voltage, Electromechanical deflection modeling, pull-in instability, switching time and pull-in voltage scaling, Physical effects in nanoscale gap-size, squeeze-film damping , perforated MEMS Capacitive switch, Comb actuators, Accelerometer, Pressure sensor, Energy approach: Lagrangian Mechanics applicable to MEMS capacitive switches, Reliability in RF-capacitive switch

MEMS DEVICES (09 Hours)

Architecture, working and basic quantitative behaviour of Cantilevers, Microheaters, Accelerometers, Pressure Sensors, Micromirrors in DMD, Inkjet printer-head. Thermal sensor design, Bio-MEMS, MEMS memory, Optical MEMS:2-D, 3-D switches.

MEMS DEVICE CHARACTERIZATION (03 Hours)

Piezoresistance, TCR, Stiffness, Adhesion, Vibration, Resonant frequency, Laser Doppler vibrometer, Electronic Speckle Interference Pattern technology (ESPI), and the importance of these measurements to study device behavior, MEMS Reliability.

3. Books Recommended

1. E. S. Kim, “Fundamentals of Microelectromechanical Systems (MEMS)”, McGraw Hill, 2021.
2. Tai–Ran Hsu, “Mems & Microsystems Design and Manufacturing”, John Wiley & Sons, 2nd Edition, 2008
3. Chang Liu, “Foundations of MEMS”, Pearson Education Inc., 2006.
4. Sandana A., “Engineering biosensors: kinetics and design applications”, Academic Press 2002
5. Marc J. Madou, “Fundamentals of Microfabrication”, 2nd Edition, CRC Press Taylor and Francis Group, 6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL33487- 2724, 2002.

4. Reference Recommended

1. Ville Kaajakari, “Practical MEMS”, Small Gear Publishing, 2009
2. S. Senturia “Microsystem Design”, 1st Edition, Springer, 2000
3. Minhang Bao, “Analysis and Design Principles of MEMS Devices”, 1st Edition, - Elsevier Science, 2005
4. J. Allen, “Micro Electro Mechanical System Design”, 1st Edition, CRC Press, 2005
5. G. Kovacs, “Micromachined Transducers Sourcebook”, 2nd Edition, McGraw-Hill, 2000

M.Tech. I (VL) Semester – II Foundation of VLSI CAD ECVL174	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Understand CAD tools used for VLSI design and synthesis
CO2	Optimize the algorithms for portioning in the design process of Complex IC
CO3	Demonstrate capability of floorplanning algorithm for CAD tool
CO4	Analyze various algorithms for Placement and Routing.
CO5	Investigate timing analysis and understand Timing Closure

2. Syllabus

INTRODUCTION TO VLSI CAD AND SYNTHESIS (06 Hours)

Intro to VLSI CAD & Logic Synthesis • Graph Theory & Optimization problems • Boolean Algebra • Boolean Function Representation & Manipulation: BDDs • Satisfiability & Graph Covering

NETLIST AND SYSTEM PARTITIONING (08 Hours)

Optimization Goals, Partitioning Algorithms: Kernighan-Lin (KL) Algorithm, Extensions of the Kernighan-Lin Algorithm, Fiduccia-Mattheyses (FM) Algorithm, A Framework for Multilevel Partitioning, Clustering, Multilevel Partitioning, System Partitioning onto Multiple FPGAs...

CHIP PLANNING (08 Hours)

Introduction to Floorplanning, Optimization Goals in Floorplanning, Floor Plan Representations, Floorplanning Algorithms, Pin Assignment, Power and Ground Routing

GLOBAL AND DETAILED PLACEMENT AND ROUTING (12 Hours)

Global Placement, Min-Cut Placement, Analytic Placement, Simulated Annealing, Modern Placement Algorithms, Legalization and Detailed Placement, The Global Routing Flow: Single-Net Routing; Rectilinear Routing; Global Routing in a Connectivity Graph; Finding Shortest Paths with Dijkstra's Algorithm; Finding Shortest Paths with A* Search, Full-Netlist Routing: Routing by Integer Linear Programming; Rip-Up and Reroute (RRR), Modern Global Routing: Pattern Routing; Negotiated Congestion Routing, Detailed Routing, Specialized Routing

TIMING CLOSURE (11 Hours)

Timing Analysis and Performance Constraints: Static Timing Analysis; Delay Budgeting with the Zero-Slack Algorithm, Timing-Driven Placement: Net-Based Techniques; Embedding STA into Linear Programs for Placement, Timing-Driven Routing: The Bounded-Radius, Bounded-Cost Algorithm; Prim-Dijkstra Tradeoff; Minimization of Source-to-Sink Delay, Physical Synthesis: Gate Sizing; Buffering; Netlist Restructuring

Total Contact Time: = 45 Hours

3. Books Recommended

1. Andrew B. Kahng, Jens Lienig, Igor L. Markov, Jin Hu, " VLSI Physical Design: From Graph Partitioning to Timing Closure ", Springer Cham, 2023.
2. Khosrow Golshan, " Physical Design Essentials ", Springer New York, NY, 2010.
3. De Micheli, Synthesis and optimization of Digital Circuits, Tata McGraw Hill, 2003.
4. Sadiq M Sait, Habib Youssef, " VLSI Physical Design Automation Theory and Practice ", , World Scientific Publishing Company, 1999
5. Naveed A. Sherwani, " Algorithms for VLSI Physical Design Automation ", Springer New York, NY, 2013

M.Tech. I (VL) Semester – II SEMICONDUCTOR DEVICE MODELLING ECVL176	Scheme	L	T	P	Credit
		3	0	0	03

1.	Course Outcomes (COs): At the end of the course, the students will be able to
CO1	Describe semiconductor device physics and equations used for deriving a model.
CO2	Demonstrate various carrier transport equations.
CO3	Analyze methods to form closed-form analytical models.
CO4	Evaluate the operation of semiconductor devices using numerical methods.
CO5	Develop models for novel semiconductor devices.

2. Syllabus

DEVICE PHYSICS (03 Hours)

Review of Semiconductor Physics: PN Junction diode, Heterojunctions, MOSFETS.

SEMICONDUCTOR CARRIER TRANSPORT EQUATIONS (07 Hours)

The Boltzmann model, Maxwell's Equations, The Classical Semiconductor Equations, Boundary Conditions, Generation and Recombination, and Thermal Conductivity and Heat Flow.

CLOSED-FORM ANALYTICAL MODELS (08 Hours)

Solution Techniques for the Semiconductor Equations, Closed-Form Analysis of the Semiconductor Equations, Analysis of a PN junction diode, Analysis of Field effect Transistor Operation, Analysis of MOSFET Operation and Limitations of Closed-Form Analyses

FINITE-DIFFERENCE METHOD (06 Hours)

Finite-Difference Schemes, Discretization of the Semiconductor Equations, Methods of Solving the Finite-Difference Equations, Boundary Conditions, and Examples of Finite-Difference Simulations.

SEMICLASSICAL TRANSPORT EQUATIONS (06 Hours)

Hot Electron Effects: The Hydrodynamic Semi-classical Semiconductor Equations, Examples of Hot Electron Modelling

SIMULATION OF HETEROJUNCTION DEVICES (05 Hours)

Semiconductor Equations for Heterojunctions, High Electron Mobility Transistors: Closed-Form Models and Numerical Models.

THE MONTE CARLO METHOD **(05 Hours)**

The Monte Carlo Method applied to Carrier Transport in Semiconductors: Equations of Motion, Energy Band Structure and Free Flight, and Scattering Mechanisms, Treatment of Results, and Applications of Monte Carlo Simulations.

QUANTUM TRANSPORT THEORY **(05 Hours)**

Extension of Semiclassical Transport Concepts to Quantum Structures, Quantum mechanics – Basic Concepts, Application of Quantum Mechanics to Semiconductor Device Modelling, Quantum Transport Theory, and Applications of Quantum Transport Theory

Total Contact Time: = 45 Hours

3. Books Recommended

1. Snowden C.M., and, Snowden E., “Introduction to Semiconductor Device Modeling”, World-Scientific, 1998.
2. Selberherr S., “Analysis and Simulation of Semiconductor Devices”, Springer-Verlag, First edition, 1984.
3. Taur Y. and Ning T.H. “Fundamentals of Modern VLSI Devices, “, Cambridge University Press, Third Edition, 2021.
4. Vasileska D., Goodnick S. M., and Klimeck G., “Computational Electronics Semiclassical and Quantum Device Modeling and Simulation, CRC Press, 2010.
5. Sze S. M., Li Y., and Kwok K. Ng, “Physics of Semiconductor Devices”, John Willey, Fourth Edition, 2021.

M.Tech. I (VL) Semester – II LOW POWER VLSI DESIGN ECVL112	Scheme	L	T	P	Credit
		3	0	0	03

1.	Course Outcomes (COs): At the end of the course, the students will be able to
CO1	Understand the physics of power dissipation in CMOS
CO2	Estimate power that occurs due to various signal and circuit phenomena
CO3	Design low power CMOS circuits
CO4	Analyze VLSI Design Methodologies for achieving low power
CO5	Evaluate algorithms for power estimation and optimization

2. Syllabus

PHYSICS OF POWER DISSIPATION IN CMOS **(08 Hours)**

Submicron MOSFET, Gate induced drain leakage, Short circuit dissipation, Dynamic dissipation, Load capacitance, Low power limits: Hierarchy limits, fundamental limits, device limit, circuit limit, system limit

POWER ESTIMATION **(08 Hours)**

Probabilistic Techniques for Signal activity Estimation, Statistical Technique to estimate average power, Estimation of Glitch power, Power sensitivity analysis, Input vector compaction, Domino CMOS, Circuit reliability, High level power estimation, Estimation of maximum power

DESIGN OF LOW POWER CMOS CIRCUITS **(09 Hours)**

Circuit Design Styles, Leakage current and submicron device issues, Low voltage circuit design techniques, Multiple supply voltages

VLSI DESIGN METHODOLOGY FOR LOW POWER **(10 Hours)**

Low power physical design, Low power gate level design (Logic minimization, spurious transition reduction and precomputation based reduction), Low power architectural level design (parallelism, pipelining, distributed processing and power management) , Algorithmic level power reduction (switched capacitance and switching activity reduction

ALGORITHMS FOR LOW POWER **(10 Hours)**

Algorithms for power estimation (Gate level, Architectural level, Instruction level and bus switching activity), Power optimization: Algorithm transformations, minimizing memory access, Instruction selection/ordering and power management, Automated low power code generation, Codesign for Low power

Total Contact Time: = 45 Hours

3. Books Recommended

1. Kaushik Roy, Sharat C. Prasad, “Low-Power Cmos Vlsi Circuit Design”, John Wiley & Sons, 2009.
2. A. Bellamour, and M. I. Elmasri, “Low Power VLSI CMOS Circuit Design”, Springer US, 2012.
3. Anantha P. Chandrakasan and Robert W. Brodersen, “Low Power Digital CMOS Design”, Kluwer Academic Publishers, 2012.
4. Christian Piguet, “Low-Power CMOS Circuits: Technology, Logic Design and CAD Tools”, Tayler and Francis (CRC), 2006.
5. Sung-Mo Kang and Y. Leblebici, “CMOS Digital Integrated Circuits”, Tata Mcgrag Hill, 3rd edition, 2003

M.Tech. I (VL) Semester – II VLSI Architectures for DSP ECVL114	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Describe DSP algorithms using data flow graphs and various VLSI architectures for signal processing.
CO2	Apply fast convolution methods for optimization.
CO3	Analyze critical path algorithm and strength reduction.
CO4	Evaluate signal processing architectures based on area and power.
CO5	Design VLSI architectures for the signal processing based on specifications.

2. Syllabus

DSP CONCEPTS **(10 Hours)**

Linear system theory, DFT, FFT, DCT realization of digital filters. Typical DSP algorithms, DSP applications, Data flow graph presentation of DSP algorithm.

ARCHITECTURAL ISSUES **(13 Hours)**

Binary Adders, Binary multipliers, Multiply Accumulator (MAC) and Sum of Product (SOP). Pipelining and Parallel Processing, Retiming, Unfolding, Folding, Register Minimization Technique and Systolic architecture design, Coordic Architecture, Distributed Arithmetic Architecture

FAST CONVOLUTION **(11 Hours)**

Cook-Toom algorithm modified Cook-Toom algorithm, Winograd algorithm, modified Winograd algorithm, Algorithmic strength reduction in filters and transforms, DCT and inverse DCT, parallel FIR filters.

POWER ANALYSIS IN DSP SYSTEMS **(11 Hours)**

Scaling versus power consumption, power analysis, power reduction techniques, power estimation techniques, low power IIR filter design, Low power CMOS lattice IIR filter.

Total Contact Time: = 45 Hours

3. Books Recommended

1. Keshap K. Parhi, “VLSI Digital Signal Processing Systems, Design and Implementation”, 1st Ed., John Wiley, 2007.
2. Keshab K. Parhi and Takao Nishitani, Marcel Dekker “Digital Signal Processing for Multimedia Systems”, 1st Ed., CRC Press, 1999.
3. U. Meyer-Baese, “Digital Signal processing with Field Programmable Arrays”, 3rd Ed., Springer, 2007.
4. V. K. Madisetti, “VLSI Digital Signal Processors: An Introduction to Rapid Prototyping and Design Synthesis”, IEEE Press, New York, 1995.
5. S. Y. Kung, H. J. Whitehouse, “VLSI and Modern Signal Processing”, 1st Ed., Prentice Hall, 1985.

M.Tech. I (VL) Semester – II VLSI SYSTEM DESIGN ECVL116	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Describe systems levels issues related to interconnect and its solution.
CO2	Apply the system decompositions in data path and control path.
CO3	Analysis of sequential logic circuit design.
CO4	Evaluate various Timing issues and its solutions.
CO5	Design systems with shared memory architecture.

2. Syllabus

INTERCONNECT (12 Hours)

The Wire, Interconnect Parameter, Electrical and Spice Wire Model, RLC Parasitic, Signal Integrity and High Speed Behavior Of Interconnects: Ringing, Cross Talk And Ground Bounce. Layout Strategies at IC And Board Level for Local and Global Signals, Power Supply Decoupling, Advance Interconnect Techniques. Clocking strategy.

SYSTEM HARDWARE DECOMPOSITION (10 Hours)

VLSI Design Flow, Mapping Algorithms into architectures, Data Path And Control Path, Register Transfer Level Description, Control Path Decomposition (Interfacing With FSM), Pitfalls of Decomposition, Critical Path and worst case timing analysis, Control Flow And Data Flow Pipelines, Communication Between Subsystems, Control Deadlocks. Concept of hierarchical system design; Data-path element: Data-path design philosophies, fast adder, multiplier, driver etc. Timing And Control Shared Memory Data Hazards And Consistency, Mutual Exclusion.

DESIGNING OF SEQUENTIAL LOGIC CIRCUIT (10 Hours)

Timing classification; Synchronous design; Self-timed circuit design; Clock Synthesis and Synchronization: Synchronizers; Arbiters; Clock Synthesis; PLLs; Clock generation; Clock distribution; Synchronous Vs Asynchronous Design, Static And Dynamic Latches And Registers, Design And Optimization Of Pipelined Stages, Timing Issues In Digital Circuits, Handling Multiple Clock Domains, Interface Between Synchronous And Asynchronous Blocks, Set-Up And Hold Time Violation, Concept Of Meta-Stability.

MEMORY SUBSYSTEM DESIGN (13 Hours)

Memory Architecture, Shared Memory Architecture, Data Hazards and Consistency, Mutual Exclusion

Total Contact Time: = 45 Hours

3. Books Recommended

1. Rabaey Jan M., Chandrakasan Anantha and Borivoje Nikolic, "Digital Integrated Circuits (Design Perspective)", 2nd Ed., Prentice Hall of India, 2016 (Reprint).
2. Neil H. E. Weste, David. Harris and Ayan Banerjee,, “CMOS VLSI Design”, 4th Ed., Pearson Education, 2019
3. Smith M. J. S., "Application Specific Integrated Circuits", 1st Ed., Addison Wesley, 1999.
4. Dally W. J. and Poulton J. W., "Digital System Engineering", 1st Ed., Cambridge University Press, 1998.
5. Hall S. H., Hall G. W. and McCall J. A., "High Speed Digital System Design", 1st Ed., John Wiley & Sons, 2000.
6. Bakoglu H. B., "Circuit Interconnect and Packaging For VLSI", 1st Ed., Addison-Wesley, 1990.
7. Laung-Terng Wang, Cheng-Wen Wu and Xiaoqing Wen, "VLSI Test principles And Architectures Design For Testability", 1st Ed., Morgan Kaufmann Publishers, 2006.

4. Reference Books

1. Bakoglu H. B., "Circuit Interconnect and Packaging For VLSI", 1st Ed., Addison-Wesley, 1990.
2. Laung-Terng Wang, Cheng-Wen Wu and Xiaoqing Wen, "VLSI Test principles And Architectures Design For Testability", 1st Ed., Morgan Kaufmann Publishers, 2006.

M.Tech. I (VL) Semester – II SOC DESIGN ECVL118	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Understand and estimate key design metrics and requirements including area, latency, throughput, energy, power.
CO2	Implement both hardware and software solutions, formulate hardware/software trade-offs, and perform hardware/software codesign
CO3	Analyze issues in system-on-chip design associated with Interconnection Structures, performance and power consumption
CO4	Use of SystemC programming and HLS
CO5	Design and optimize a modern System-on-a-Chip

2. Syllabus

SOC DESIGN APPROACH (08 Hours)

Basics of Chips and SoC ICs, SoC Design: SoC CPU/IP Cores; Co-processor; Cache; DRAM Controller, SoC Synthesis, Static Timing Analysis (STA), Design for Testability, Verification, Physical Design

HARDWARE-SOFTWARE CO-SYNTHESIS (09 Hours)

Partitioning, Cycle Time, Die Area-and-Cost, Power, Area-time-Power Trade-offs and Chip Reliability, Real-time scheduling, hardware acceleration

VIRTUAL PROTOTYPING AND HLS (10 Hours)

Mapping High-Level Language Applications to Hardware, Transaction-Level Modeling & Electronic System-Level Languages, Hardware Accelerators, Media Instructions, Co-processors, System-Level Design Methodology, High-Level Synthesis (C-to-RTL), Hardware Synthesis and Architecture Techniques, Source-Level Optimizations

SOC INTERCONNECTION STRUCTURES: (10 Hours)

Bus-based Interconnection, Bus protocols: AMBA AXI Bus; AXI4-Stream; IBM Core Connect; Avalon, Interconnection Structures, Network on Chip - NoC Interconnection and NoC Systems, IP interfacing

PERFORMANCE / POWER ANALYSIS OF SOCS (08 Hours)

System-level modeling and integration, Simulation platform for performance analysis of SoC/MPSoC, Use cases and examples.

Total Contact Time: = 45 Hours

3. Books Recommended

1. Veena Chakravarthi, “A Practical Approach to VLSI System on Chip (SoC) Design-A Comprehensive Guide”, Springer, 2020
2. S. Pascricha and N. Dutt, “On-Chip Communication Architectures, System on Chip Interconnect”, Morgan Kaufmann-Elsevier Publishers, 2008,
3. Keating, M., “The Simple art of SoC design”, Springer, 2011,.
4. P. Schaumont, “A Practical Introduction to Hardware/Software Co-design”, Springer, 2009,
5. Ghenassia, F., “Transaction-level modeling with SystemC: TLM concepts and applications for embedded systems”, Springer, 2010
6. Grotker, T., Liao, S., Martin, G. & Swan, S., “System design with SystemC”, Springer, 2002

M.Tech. I (VL) Semester – II CMOS RF IC Design ECVL120	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Select a transceiver specification appropriate for the communication link.
CO2	Demonstrate Analog and Digital Modulation for RF circuits.
CO3	Analyze the Low Noise Amplifier (LNA).
CO4	Evaluate the appropriate mixers and oscillators for the desired applications.
CO5	Design of PLL using appropriate loop filter, phase detector and frequency synthesizer.

2. Syllabus

INTRODUCTION TO RF AND WIRELESS TECHNOLOGY: (08 Hours)

Complexity, design and applications. Choice of Technology. Basic concepts in RF Design: Nonlinearly and Time Variance, inter-symbol Interference, random processes and Noise. Definitions of sensitivity and dynamic range, conversion Gains and Distortion, S-parameters with Smith chart, Passive IC components.

POWER AMPLIFIERS AND MATCHING NETWORKS (06 Hours)

Class A, AB, B and C Power amplifiers, modulation and characteristics of power amplifiers, Design examples. Impedance transformations and matching; L-matches, Pi- & T-matches, tapped-capacitor match.

LOW NOISE AMPLIFIERS (12 Hours)

LNA Topologies: Common-Source Stage with Resistive Feedback, Common Gate, Cascode CS Stage with Inductive Degeneration, Variants of Common-Gate LNA, Noise-Cancelling LNAs, Reactance-Cancelling LNAs Gain Switching, Band Switching, Differential LNAs, Nonlinearity Calculation

MIXERS AND OSCILLATORS (11 Hours)

Design of Mixers at GHz frequency range. Various Mixers, their working and implementations, Oscillators: Basic topologies VCO and definition of phase noise. Noise-Power trade-off. Resonatorless VCO design. Quadrature and single-sideband generators

PLL AND FREQUENCY SYNTHESIZERS (08 Hours)

Radio Frequency Synthesizes: PLLS, Various RF synthesizer architectures and frequency dividers, Power Amplifiers design. Linearisation techniques, Design issues in integrated RF filters, Some discussion on available CAD tools for RF VLSI design

Total Contact Time: = 45 Hours

3. Books Recommended

1. T. H. Lee, “The Design of CMOS RF Integrated Circuits”, Cambridge, 2012.
2. B.Razavi, “RF Microelectronics”, Pearson Education, 2013.
3. B.Razavi, “Design of Analog CMOS Integrated Circuits”, McGraw Hill, 2001.
4. C.C. Enz and E.A. Vittoz, Charge-based MOS transistor Modelling The EKV Model for Low-Power and RF IC Design By, Wiley, 2006
5. Christopher Bowick, “RF Circuit Design”, Newnes, 2007

M.Tech. I (VL) Semester – II NANOSCALE DEVICES ECVL122	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Understand the MOS Device Engineering nanoscale
CO2	Describe and illustrate Non Classical MOS Device Structures
CO3	Analyze Emerging Nanoscale Devices and its property
CO4	Evaluate the Ballistic theory of carrier transport and Model the characteristics the nanoscale MOS Devices
CO5	Design the Nanoscale Memory and different emerging memory devices.

2. Syllabus

MOS DEVICE ENGINEERING **(07 Hours)**

CMOS Scaling, Channel, and Source Drain Engineering. Gate Oxide Scaling and Reliability, High K Dielectrics, Metal Gate Transistor, Effect of non-idealities in CV characteristics, Subthreshold slope engineering.

NON-CLASSICAL TRANSISTORS **(11 Hours)**

Silicon on Insulator (SOI) MOSFETs, Partially Depleted (PD) SOI MOSFETs, Fully Depleted (FD) SOI MOSFETs, Ultrathin Body (UTB) SOI, Fin FET, Surround Gate FET, Germanium Based MOSFETs, Schottky Barrier S/D MOSFETs, Strained Layer High Mobility MOSFETS, GaAs FETs,HEMTS: Modulation (delta) Doping, Analysis of III-V Heterojunctions, Charge Control, I-V characteristics, HBTs: Structure, Basic Operation, Technological Aspects, I-V characteristics

EMERGING MOS DEVICES **(10 Hours)**

Junctionless MOSFET, Tunnel FETs, Negative Capacitance FETS.Beyond Silicon Technology: Organic FETs, 2D-Materials Based FETs: CNT, Nanowire, MOS2, MOSe2, Black Phosphorus, and current trends.

MODELLING OF NANOSCALE MOSFETS **(10 Hours)**

Ballistics Transport, NEGF Formalism, Physical view of the nanoscale MOSFETs, Natori's theory of the ballistic MOSFET, Nondegenerate, degenerate, and general carrier statistics The ballistic MOSFET, Quantum Transport in Nanoscale MOSFETs, Role of the quantum capacitance, Scattering Theory of the MOSFETs

NANOSCALE MEMORY DEVICES **(07 Hours)**

Emerging memory technologies: Phase Change Memory (PCM); Resistive Random-Access Memory; Magnetoresistive Random Access Memory (MRAM); Ferroelectric Random-Access Memory (FeRAM); MOTT Memory, Comparison and future directions.

Total Contact Time: = 45 Hours

3. Books Recommended

1. Taur and Ning, “Fundamentals of Modern VLSI Devices” Cambridge University Press, 2009.
2. M. S Lundstrom and J. Guo,“Nanoscale Transistors: Device Physics, Modeling and Simulation” Springer, 2006
3. D Esseni P Palestri and L Selmi,“Nanoscale MOS Transistors: Semi-Classical Transport and Applications”, Cambridge University Press, 2011.
4. Tseung-Yuen Tseng and Simon M. Sze, “Nonvolatile memories-Materials, Devices and Applications”, American Scientific Publishers, 2012
5. Simone Raoux and Matthias Wuttig, “Phase change materials-Science and Applications”, Springer 2009

M.Tech. I (VL/CS) Semester – II SEMICONDUCTOR PACKAGING ECVL124	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Understand the traditional packaging technologies and the process involved
CO2	Demonstrate various advanced packaging materials, substrates, technologies, interconnects, and thermal management.
CO3	Analyze the reliability of advanced packaging technologies
CO4	Evaluation of emerging technologies in the field of packaging.
CO5	Design of Semiconductor Packaging

2. Syllabus

INTRODUCTION TO SEMICONDUCTOR PACKAGING (09 Hours)

Definition of packaging and its significance in various industries; Introduction to packaging and its importance in Modern Electronics.
Traditional packaging technologies: Leaded and leadless packages, surface mount technology (SMT), and ball grid array (BGA).

ADVANCED PACKAGING (12 Hours)

Introduction to advanced packaging: Advanced packaging and its importance in evolving technology requirements. Benefits and challenges of advanced packaging. Advanced packaging integrated technology: 2.5D and 3D packaging, Optoelectronics packaging, MEMS and Sensors packaging, Memory packaging
Advanced packaging interconnects: Interconnect technologies in advanced packaging: flip chip bumping, solder balls, and through-silicon vias (TSVs).

ADVANCED PACKAGING MATERIALS AND SUBSTRATES (08 Hours)

Substrates and materials used in advanced packaging, such as organic substrates, build-up substrates, redistribution layers (RDLs), interposers, and fan-out substrates. Substrates and materials: properties, fabrication techniques, and performance characteristics.

THERMAL MANAGEMENT IN ADVANCED PACKAGING (05 Hours)

Importance of thermal management in advanced packaging.
Thermal management techniques: heat sinks, thermal interface materials (TIMs), and thermal vias.

TESTING AND RELIABILITY IN ADVANCED PACKAGING (06 Hours)

The testing methodologies and reliability considerations specific to advanced packaging. Package-level testing, interconnect testing, and reliability testing. Failure analysis techniques and strategies for package reliability.

FUTURE TRENDS AND EMERGING TECHNOLOGIES (05 Hours)

Emerging trends in advanced packaging and their potential impact. Future developments and opportunities in the field.

Total Contact Time: = 45 Hours

3. Books Recommended

1. Fundamentals of Device and Systems Packaging Technologies and Applications by Rao R. Tummala, McGraw-Hill Publications, Second Edition, 2019.
2. Microelectronics Packaging Handbook by Rao R. Tummala, Eugene J. Rymaszewski, and Alan G. Klopfenstein, Springer, 1997.
3. Semiconductor Advanced Packaging by John. H. Lau, Springer, 2021
4. Semiconductor Packaging: Materials Interaction and Reliability, Chen, Andrea, Lo, Randy Hsiao-Yu, CRC Press, 2011.
5. 3D IC Integration and Packaging 1st Edition by John H. Lau, McGraw Hill, 2015.

Additional Resources:

1. Relevant Journal and Conference publications.

M.Tech. I (VL) Semester – II NEUROMORPHIC COMPUTING ECVL126	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Understand the fundamentals of Neuro Science
CO2	Use the concepts of Neroscience for neuromorphic design
CO3	Analyze principles of spiking neural networks
CO4	Apply neuromorphic engineering for real-life problems
CO5	Design spiking neural networks using various approaches

2. Syllabus

FUNDAMENTALS OF NEURO SCIENCE (09 Hours)

Introduction to Neuromorphic Engineering; Signaling and operation of biological neurons, neuron models, signal encoding and statistics; Synapses and plasticity rules, biological neural circuits;

NEUROMORPHIC DESIGN PRINCIPLES (10 Hours)

FETs - device physics and sub-threshold circuits; Analog and digital electronic neuron design; Non-volatile memristive semiconductor devices; Electronic synapse design;

OPERATIONAL PRINCIPLES AND LEARNING IN SPIKING NEURAL NETWORKS (09 Hours)

Spiking Neural Networks, Learning in Shallow SNNs, Learning in Deep SNNs, Learning Through Modulating Weight-Dependent STDP in Multilayer Neural Networks, Simulation Results,

HARDWARE IMPLEMENTATIONS OF SPIKING NEURAL NETWORKS (10 Hours)

The Need for Specialized Hardware, Digital SNNs: Large-Scale SNN ASICs; Small/Moderate-Scale Digital SNNs; Hardware-Friendly Reinforcement Learning in SNNs; Hardware-Friendly Supervised Learning in Multilayer SNNs, Analog/Mixed-Signal SNNs: Basic Building Blocks; Large-Scale Analog/Mixed-Signal CMOS SNNs; Other Analog/Mixed-Signal CMOS SNN ASICs; SNNs Based on Emerging Nanotechnologies; Case Study: Memristor Crossbar Based Learning in SNNs

ADVANCES IN NEUROMORPHIC COMPUTING (07 Hours)

Brain-Inspired Neuromorphic computing, Neuromorphic Hearing, Neuromorphic Vision

Total Contact Time: = 45 Hours

3. Books Recommended

1. Dale Purves, “Neuroscience”, Sinauer, 3rd Ed., 2011,
2. Carver Mead, “Analog VLSI and Neural Systems”, Addison-Wesley, 1989,
3. Nan Zheng, Pinaki Mazumder, “Learning in Energy-Efficient Neuromorphic Computing: Algorithm and Architecture Co-Design”, Wiley, 2019
4. Richard F. Lyon, Tor Sverre Lande, “Neuromorphic Systems Engineering: Neural Networks in Silicon”, Springer US, 1998
5. Eric Kandel, James Schwartz, Thomas Jessell, Steven Siegelbaum, A.J. Hudspeth, “Principles of neural science”, McGraw Hill 2012,
6. Khaled Salah Mohamed, “Neuromorphic Computing and Beyond”, Springer International Publishing, 2020
7. Steve Furber (ed.), Petrut Bogdan (ed.), "SpiNNaker: A Spiking Neural Network Architecture", Boston-Delft: now publishers, 2020

M.Tech. I (VL) Semester – II MIXED SIGNAL IC DESIGN ECVL128	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Understand sample and hold circuits based on CMOS and BiCMOS. Compare and contrast various S/H circuits.
CO2	Apply advanced techniques for bandgap references, comparators, current mirrors and operational amplifiers.
CO3	Evaluate concepts of Oversampled ADCs, Noise shaping and decimation filtering. Propose and design sigma-delta architecture based on specification
CO4	Analyze a variety of data converters. Compare architectures based on various metrics.
CO5	Design of various mixed signal blocks

2. Syllabus

SAMPLE AND HOLD CIRCUITS (8 Hours)

Sample & hold and translinear circuits - performance and testing of sample and hold circuits, examples of CMOS S/H circuits, bipolar and BiCMOS S/H circuits, translinear gain cell and multipliers. Switched capacitor circuits - opamps, capacitors, switches, non-overlapping clocks

SWITCHED CAPACITOR CIRCUITS (6 Hours)

Basic operation and analysis of switched capacitor circuits, resistor equivalence of a switched capacitor, noise in switched-capacitor circuits. Comparators - specifications, opamp as a comparator, latched comparators, examples of CMOS comparators

A TO D AND D TO A CONVERTERS (12 Hours)

Data convertors - ideal D/A and A/D convertors, quantization noise, accuracy and linearity. Nyquist rate DAC - Decoder-based converter, Binary-scaled converters, Thermometer-code converters, Hybrid converters. Nyquist rate ADC - Successive-approximation converters, Algorithmic (or cyclic) A/D Converter, Pipelined A/D converters, Two-step A/D converters, Interpolating A/D converters, folding A/D converters, time-interleaved A/D converters

OVERSAMPLED DATA CONVERTERS (12 Hours)

Oversampling ADCs - Oversampling without noise shaping - quantization noise modeling, white noise assumption, • oversampling advantage, the advantage of 1-bit D/A converters. Oversampling with noise shaping - noise-shaped delta-sigma modulator, first-order noise shaping, switched-capacitor realization of a first-order A/D converter, quantization noise power of 1-bit modulators. System architectures, Digital decimation filters, Multi-bit oversampling converters

MIXED SIGNAL SUBCIRCUITS (7 Hours)

Linearized PLL models, Design of PLL's and DLL's and frequency synthesizersVCO, Jitter and phase noise, Electronic oscillators

Total Contact Time: = 45 Hours

3. Books Recommended

1. Tony Chan Carusone, David A. Johns, Kenneth W. Martin, “Analog Integrated Circuit Design”, 2nd Edition, John Wiely & Sons, 2012.
2. B. Razavi, “Principles of Data Conversion System Design”, 1st Edition, Wiley-IEEE Press, 1994
3. R. J. Baker, “CMOS Mixed Signal circuit Design”, 2nd Edition, Wiley 2008
4. M.Gustavsson, J. J. Wikner, and N. N. Tan, "CMOS Data Conversion for Communications", Kluwer 2000.
5. Emad N. Farad and Mohamed I. Elmasry, “Mixed Signal VLSI Wireless Design: Circuits and Systems”, Kluwer 2002

M.Tech. I (VL/CS) Semester – II MEMORY TECHNOLOGY ECVL130	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Understand fundamental concepts of different memory technologies
CO2	Implement of static RAM & dynamic RAM
CO3	Compare the various memory technologies
CO4	Evaluate the various memory technologies
CO5	Design different advanced memory technologies

2. Syllabus

INTRODUCTION TO MEMORY TECHNOLOGIES (08 Hours)

Memory organization and overview of memory technology: market, trends and technologies, Overview of volatile and non-volatile memory technology, Static Random-Access Memory (SRAM), Dynamic RAM (DRAM), 1T-1C architecture, Capacitorless-DRAM, On-chip memory, on-chip memory types.

STATIC RAM (10 Hours)

Static Random Access Memories (SRAMs), SRAM Cell Structures, MOS SRAM Architecture, MOS SRAM Cell and Peripheral Circuit, Bipolar SRAM, Advanced SRAM Architectures, Application Specific SRAMs.

DYNAMIC RAM (9 Hours)

DRAMs, MOS DRAM Cell, Bi-CMOS DRAM, Error Failures in DRAM, Advanced DRAM Design and Architecture, Application Specific DRAMs, SRAM and DRAM Memory controllers.

FLASH MEMORY (8 Hours)

Flash memory: NOR and NAND architecture, Poole Frenkel emission and Fowler-Nordheim tunneling, floating gate (FG) and charge-trap (CT) NAND flash, reliability, scaling and multi-bit capability (MLC) 3D NAND, BICS, TCAT, V-NAND, VG NAND Flash, reliability and MLC

ADVANCED MEMORY TECHNOLOGIES (10 Hours)

High-density Memory Packing Technologies, Emerging non-volatile memories (eNVM): Resistive RAM (RRAM), unipolar and bipolar stacks, oxygen vacancy and ionic transport, reliability and endurance, Phase change memory (PCM), Ferroelectric RAM (FeRAM), Gallium Arsenide (GaAs) FRAMs, Conductive Bridge RAM (CBRAM) and Spin-transfer Torque Magnetic RAM (STT-MRAM)

Total Contact Time: = 45 Hours

3. Books Recommended

1. S. Yu, “Semiconductor Memory Devices and Circuits”, 1st Edition, CRC Press, 2022.
2. Ashok K. Sharma, “Semiconductor Memories: Technology, Testing, and Reliability”, 1st Edition, Wiley IEEE, 2013
3. Kiyoo Itoh, “VLSI Memory Chip Design”, 1st Edition, Springer, 2001
4. N. Weste and D. Harris, “CMOS VLSI Design: A Circuits and Systems Perspective”, 3rd Edition. Pearson, 2006
5. Y. Nishi and Magyari-Kope, “Advances in non-volatile memory and storage technology”, Woodhead Publishing, 1st Edition, 2019.
6. Keeth, Baker, Johnson, and Lin, “DRAM Circuit Design: Fundamental and High-Speed Topics”, 2nd Edition, Wiley, IEEE 2007.

M.Tech. I (VL/CS) Semester – II HIGH-SPEED INTERCONNECT ECVL132	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Understand the VLSI interconnect, parasitic components and interconnect technology
CO2	Analyze interconnect delay
CO3	Evaluate crosstalk
CO4	Design PLL/DLL and Clock and data recovery (CDR) / deserializers
CO5	Design Equalization and equalizers and serializers

2. Syllabus

VLSI INTERCONNECTS (05 Hours)

Interconnections for VLSI Applications-Copper Interconnections- Method of Images- Method of Moments- Even and Odd Mode Capacitances- transmission line equations- miller’s theorem- Resistive interconnects as ladder network-Propagation modes in micro strip interconnects-slow wave propagations-Propagation delay

PARASITIC COMPONENTS (05 Hours)

Parasitic resistances, capacitances and inductances- approximate formulas for capacitances- Green’s function method using Images and Fourier integral approach-network Analog method- Interconnection Capacitances and Inductances on Silicon and GaAs Substrates-Inductance extraction and copper interconnections for resistance modeling.

INTERCONNECTION DELAYS (05 Hours)

Metal insulator semiconductor micro strip line- transmission line analysis for single level interconnections, parallel multilevel interconnections and crossing interconnections- parallel interconnection models for micro strip line- modeling of lossy parallel and crossing interconnects- high frequency losses in micro strip line- Expressions for interconnection delays- Active interconnects.

CROSS TALK ANALYSIS (06 Hours)

Lumped capacitance approximation- coupled multi conductor MIS micro strip line model for single level interconnects- frequency domain level for single level interconnects-transmission line level analysis of parallel multilevel interconnections-Analysis of Crossing Interconnections- Compact Expressions for Crosstalk Analysis- Multi conductor Buses in GaAs High-Speed Logic Circuits.

Phase-locked loops (PLLs) and delay locked loops (DLLs) (06 Hours)

Basic Building blocks,pf PLL/DLL, Loop analysis, A brief overview of non-idealities in the PLLs/DLLs, Jitter and phase noise (and relationship between them), Jitter transfer functions in DLLs and PLLs, BER estimation based on jitter,

Clock and data recovery (CDR) / deserializers **(06 Hours)**

Phase detectors (linear/non-linear, full-rate/nth-rate etc. and some examples, Basic circuit level blocks: Latches, flip-flops, XOR gates, muxes etc. in Current Mode Logic (CML), Circuit level bandwidth enhancement techniques, Tunable delays using tunable delay cells and phase interpolators, Voltage controlled oscillators (VCOs), Multi-phase clock generation. g) CDR architectures

Equalization and equalizers and serializers **(06 Hours)**

Channel model and inter-symbol-interference (ISI), Pre-cursor and post-cursor ISI, Analog domain equalizers i. CTLE (continuous time linear equalizers). ii. FFE (feed-forward equalizers). iii. Non-linear equalizers (decision-feedback equalizers), Equalization in the digital domain, Equalizer training and blind equalization techniques, Eye monitor circuits for equalizers.

Transmitters and serializers: Block diagram of a serializer, LVDS (low-voltage differential signaling) and impedance matching, Pre-emphasis (FIR) equalization for transmitters

INTERCONNECTION TECHNOLOGIES **(06 Hours)**

Transmission Line Models of Lossy Waveguide Interconnections- Optical interconnects - Superconducting Interconnections- Nanotechnology Circuit Interconnections (Graphene and CNT) - Potential Technologies- Nanotube Integrated Circuits.

Total Contact Time: = 45 Hours

3. Books Recommended

1. Ashok K. Goel “High-Speed VLSI Interconnections”, 2nd Edition, Wiley-IEEE Press, August 2007.
2. S. H. Hall and H.L. Heck , Advanced Signal Integrity for High-Speed Digital Designs, John Wiley & Sons, 2009.
3. Behzad Razavi, Design of Integrated Circuit for Optical Communications, McGraw-Hill, 2003.
4. H. B. Bakoglu, Circuits, Interconnections, and Packaging for VLSI” Massachusetts: Addison-Wesley Publishing Company, 2000.
5. Hall, S.H., G. W. Hall and J. McCall, “High-Speed Digital System Design”, First Edition. Wiley-Interscience, 2000.

M.Tech. I (VL/CS) Semester – II IMAGE PROCESSING & COMPUTER VISION ECCS102	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Understand the basic of image formation and use of different image transforms with their properties.
CO2	Apply techniques for image enhancement both in spatial and frequency domains
CO3	Analyze causes for image degradation and apply restoration techniques.
CO4	Evaluate different image segmentation techniques and develop solutions using Mathematical morphology concept.
CO5	Develop the image compression techniques in spatial and frequency domains

2. Syllabus

IMAGE PROCESSING SYSTEM **(04 Hours)**

Camera Model, Image Representation, Image Sampling, Quantization, Resolution, Human Visual System, Classification of Digital Images, Image Types, Elements of an Image-processing System, Image File Formats, Relationships Between Pixels-Nearest Neighbor, Adjacency, Connectivity, Regions, and Boundaries; Distance Measures.

IMAGE ENHANCEMENT & IMAGE TRANSFORMS **(10 Hours)**

Image Enhancement in spatial domain, Enhancement through Point Operation, Histogram Manipulation, Gray-level Transformation, Neighborhood Operation, filtering operation in spatial domain, Bit-plane Slicing, Enhancement in the Frequency Domain,2D Convolution, 2D Discrete Fourier Transform, Homomorphic Filter, Zooming Operation,

IMAGE RESTORATION/DENOISING AND IMAGE REPRESENTATION & DESCRIPTION **(10 Hours)**

Linear, Position-Invariant Degradations, Estimating the Degradation Function, Inverse Filtering, Minimum Mean Square Error (Wiener) Filtering, Constrained Least Squares Filtering Classification of Noise in Image, Median Filtering, Trimmed Average Filter, Adaptive filters, Performance Metrics in Image Restoration, Applications of Digital Image Restoration. Image Image Compression Fundamentals, study of Image representation and description techniques.

IMAGE SEGMENTATION AND MATHEMATICAL MORPHOLOGY **(06 Hours)**

Point, Line, and Edge Detection, Thresholding, Region-Based Segmentation, Basic Morphological Operations-Opening, Closing Operators, Dilation and Erosion, Morphological Algorithms, Applications.

IMAGE FORMATION **(05 Hours)**

Pinhole and Perspective Projection, Image Magnification, Vanishing Point, Image Formation using Lenses, Gaussian Lens Law, Focal Length, Two Lens System, Aperture of the Lens, Lens Defocus, Blur Circle, Depth of Field, Lens Related Issues.

RECONSTRUCTION **(10 Hours)**

Light Flux, Radiant Intensity, Surface Irradiance, Scene Radiance, BRDF, Reflectance Models, Surface Orientation, Reflectance Map, Photometric Stereo, Shape from Shading, Depth from Focus, Depth from Defocus.

Total Contact Time: = 45 Hours

3. Books Recommended

1. R. C. Gonzalez, R. E. Woods, Digital Image Processing, Pearson Education. 3rd Ed.,2016
2. Jain A.K., Fundamentals of Digital Image Processing, Prentice-Hall, 2002.
3. Sonka M. Hlavac V., Boyle R., "Image Processing, Analysis and Machine Vision", Cengage Learning, 2nd Ed. Indian Reprint, 2009
4. Manas Kamal Bhuyan, “Computer Vision and Image Processing Fundamentals and Applications”, Taylor & Francis, CRC Press, 2020.
5. Pratt W.K., Digital Image Processing, John Wiley, IV Edition, 2007.
6. Berthold Horn, Robot vision, MIT press, 1986.
7. Richard Hartley, Andrew Zisserman, Multiple view geometry in computer vision, Cambridge university press, 2003.

M.Tech. I (VL/CS) Semester – II WIRELESS COMMUNICATION ECCS104	Scheme	L	T	P	Credit
		3	0	0	03

1.	Course Outcomes (COs): At the end of the course, the students will be able to
CO1	Describe the basic concepts and terminology of Communication and wireless communication
CO2	Classify the channel models, modulation schemes like spread spectrum and multicarrier modulation
CO3	Demonstrate the concept of Spread Spectrum Technology and multicarrier modulation scheme to develop a secured wireless communication link
CO4	Analyze the various channel models and modulation schemes from the perspective of wireless channel performance.
CO5	Evaluate the advanced wireless communication challenges and solutions in terms of advanced techniques

2. Syllabus

GENERAL CONSIDERATIONS **(10 Hours)**

General considerations about radio waves over wireless channel, Radio wave propagation and the atmosphere, basic propagation mechanisms, classification of fading channels, large scale fading, shadowing, small-scale fading and multipath, statistics of fading coefficient, BER of wired and wireless communication system, diversity, power profile, delay spread, coherence bandwidth, Doppler, Doppler spectrum.

SPREAD SPECTRUM MODULATION **(12 Hours)**

Basic principle of Orthogonality, spreading code, CDMA, generation and properties of PN sequence, random spreading sequence and their properties, advantages of CDMA, rake receiver, performance analysis of CDMA downlink and uplink scenarios, near far problem in CDMA

MULTI-CARRIER MODULATION AND OFDM **(13 Hours)**

Introduction to Multicarrier modulation, multicarrier transmission and reception scheme, bottleneck in multi-carrier modulation scheme, introduction to OFDM, OFDM transmission and reception schemes, cyclic prefix, carrier frequency offset in OFDM, PAPR in OFDM, SC-FDMA.

MIMO **(10 Hours)**

Introduction spatial multiplexing, MIMO system model, zero forcing receiver, MIMO-MMSE receiver, SVD based optimal MIMO transmission and reception, optimal power allocation in MIMO, space time coding, Non-linear MIMO receiver-V-BLAST, MIMO beam forming, MIMO-OFDM

Total Contact Time: = 45 Hours

3. Books Recommended

1. T. S. Rappaport, “Wireless Communications: Principles and Practice”, Pearson Education, 2nd Edition, 2010.
2. Molisch Andreas F, “Wireless Communications”, Wiley, 2nd Edition, 2011.
3. Goldsmith Andrea, “Wireless Communications”, Cambridge University Press,2002.
4. Yong Soo Cho, Jaekwon Kim, Won Young Yang, and Chung G. Kang, "MIMO-OFDM Wireless Communications with MATLAB" Wiley, 1st Edition, 2010.
5. Upena Dalal, “Wireless Communication”, Oxford University Press, 1st Edition, 2008.

M.Tech. I (VL/CS) Semester – I MICROWAVE INTEGRATED CIRCUITS ECCS116	Scheme	L	T	P	Credit
		3	0	0	03

1.	Course Outcomes (COs): At the end of the course, the students will be able to
CO1	Describe the Microstrip lines, slot lines, co-planar line, and Microwave and millimeter wave circuit.
CO2	Implement the models for passive components, active device and impedance matching network.
CO3	Analyze the design and stability of microwave integrated circuits, Substrate Integrated Waveguide, Metamaterial-Based Compact Microwave and Millimetre Wave Circuit.
CO4	Evaluate the parameter of passive microwave components, active device and impedance matching network.
CO5	Develop an ability to evaluate the performance of microwave integrated circuits by using different measurements and testing techniques.

2. Syllabus

INTRODUCTION TO MICROWAVE INTEGRATED CIRCUITS (03 Hours)

Introduction to Monolithic Microwave Integrated Circuits (MMICs), their advantages over discrete circuits, MMIC fabrication techniques, Thick and Thin film technologies and materials, encapsulation and mounting of active devices, Microstrips on semiconductor substrates.

MICRO-STRIP LINES (03 Hours)

Planar transmission lines for MICs. Method of Conformal transformation for microstrip analysis, concept of effective dielectric constant, Effective dielectric constant for microstrip, Losses in Microstrip

SLOT LINES (04 Hours)

Slot Line Approximate analysis and field distribution, Transverse resonance method and evaluation of slot line impedance, comparison with Microstrip line.

FINE LINES AND COPLANAR LINES (03 Hours)

Fin lines & Coplanar Lines. Introduction, Analysis of Fin lines by Transverse Resonance Method, Conductor loss in Fin lines. Introduction to coplanar wave guide and coplanar strips.

LUMPED ELEMENTS FOR MICS (04 Hours)

Use of Lumped Elements, Capacitive elements, Inductive elements and Resistive elements

MATCHING AND BIASING NETWORKS (03 Hours)

Impedance Matching using Discrete Components, Microstrip Line Matching Networks

FUNDAMENTALSOF CMOS TRANSISTORS FOR RFIC DESIGN (04 Hours)

MOSFET Basics, MOSFET Models, Fundamentals of Stability, Determination of Stable and Unstable Regions, Stability Consideration for N-Port Circuits, Noise Figure Circles, Constant VSWR Circles. Broadband, High Power and Multistage Amplifiers, Low Noise Amplifier Design.

MICROWAVE IC DESIGN AND MEASUREMENT TECHNIQUES (03 Hours)

MIC Measurement, Testing and Applications: MIC measurement system, measurement techniques – S parameter measurement, noise measurement, MIC applications.

SUBSTRATE INTEGRATED CIRCUITS (08 Hours)

Substrate Integrated Waveguide, Substrate Integrated Image Guide, Substrate Integrated Non-radiative Dielectric Guide, Substrate Integrated Feeding Network, Substrate Integrated Divider, Substrate Integrated Phase Shifter, Substrate Integrated Coupler, Substrate Integrated Circuit–Related Transition.

METAMATERIAL-BASED COMPACT MICROWAVE AND MILLIMETRE WAVE CIRCUIT DESIGN (10 Hours)

Designs of True-Time-Delay Lines and Phase Shifters based on CRLH TL Unit Cells, Perfect Metamaterial Absorbers in Microwave and Terahertz Bands, Metamaterial-Based Compact Filter Design, Magnetically Tunable Unidirectional Electromagnetic Devices Based on Magnetic Surface Plasmon, Compact Coplanar Waveguide Metamaterial-Inspired Lines and its use in Highly Selective and Tunable Bandpass Filters.

(Total Contact Hours: 45)

3. Books Recommended

1. K.C. Gupta, “Microwave Integrated Circuits”, 1st Ed., Wiley eastern Pvt. Ltd., 1975.
2. Inder Bahl; Maurizio Bozzi; Ramesh Garg, Microstrip Lines and Slotlines, 3rd Ed., Artech, 2013.
3. T. H. Lee, “The Design of CMOS radio Frequency Integrated Circuits”, 2nd Ed., Cambridge, 2004.
4. Xun-Ya Jiang, “Metamaterials” 1st Ed., Intech, 2012.
5. Yu Jian Cheng, “Substrate Integrated Antennas and Arrays”, 1st Ed., CRC Press, 2016.

4. Reference Books

1. Bharathi Bhat, Shiban Koul, “Stripline-like transmission Lines for Microwave Integrated Ciruits”, 1st Ed., New Age International (P) Ltd. Publishers, 2007
2. Ricardo Marques, Ferran Martin, Mario Sorolla, “Materials with Negative Parameters”, 1st Ed., Wiley Interscience, 2001.
3. David M. Pozar, “Microwave Engineering”, 4th Ed., John Wiley & Sons, 2011.

M.Tech. I (VL/CS) Semester – II SPEECH PROCESSING AND APPLICATIONS ECCS130	Scheme	L	T	P	Credit
		3	0	0	03

1.	Course Outcomes (COs): At the end of the course, the students will be able to
CO1	Define the fundamentals of speech processing.
CO2	Describe the different parameters of speech signal.
CO3	Apply different algorithm to extract different speech parameters.
CO4	Analyze different speech processing algorithm.
CO5	Design a speech based system for different applications.

2. Syllabus

INTRODUCTION **(05 Hours)**

Speech processing applications, Stationary and non-stationary signal, Stationary and non-stationary analysis of speech signal, Representation of speech signal.

SPEECH FUNDAMENTAL **(06 Hours)**

Basic concepts: speech production and speech perception, Speech production model, Articulatory phonetics and speech sounds, Pitch frequency and Formant frequency, Speech segmentation: voiced, unvoiced and silence, vowel, semi-vowel, consonants, diphthongs, nasal etc.

TIME DOMAIN ANALYSIS OF SPEECH SIGNAL **(06 Hours)**

Short-term processing of speech signal, Window function, Time domain analysis, Short-time energy, Short-time autocorrelation, Short-time zero crossing, Pitch estimation, Speech vs silence classification based on short-time energy and zero crossing rate.

FREQUENCY DOMAIN ANALSIS OF SPEECH SIGNAL **(06 Hours)**

Discrete Fourier Transform, Short-term Fourier transform (STFT), Filter-bank analysis, Spectrogram analysis, Cepstrum analysis, Pitch and formant estimation

LINEAR PREDICTION ANALYSIS **(10 Hours)**

Prediction, Linear prediction, Prediction model: All pole model and Pole zero model; Autocorrelation and covariance method; Levinson-Durbin algorithm; Inverse filtering; LP residual; Pitch frequency and formant frequency analysis using LP analysis.

SPEECH PATHOLOGY DETECTION **(06 Hours)**

Feature investigation, Feature extraction: Mel frequency cepstral coefficient (MFCC) and Linear prediction coefficient (LPC), Nonlinear features, Modelling (training/classification) based on machine learning and deep learning

SPEECH EMOTION CLASSIFICATION **(06 Hours)**

Effect of emotional state on speech signal, Pitch and formant analysis for different emotions, Significance of databases: acted, evoked and natural, Emotion impacted feature extraction, feature selection, Machine learning and deep learning based emotion classification.

Total Contact Time: = 45 Hours

3. Books Recommended

1. L. R. Rabiner and R. W. Schafer, “Digital Processing of Speech Signals”, 1st Ed., PearsonEducation India, 2003.
2. J. Benetsy, M. M. Sondhi and Y. Huang, “Springer Handbook of Speech Processing”, 1st Ed., Springer Verlag, 2008.
3. J. R. Deller, Jr., J. H. L. Hansen and J. G. Proakis “Discrete-Time Processing of Speech Signals”, Wiley- IEEE Press, IEEE Edition, NY, USA, 1999.
4. D. O’Shaughnessy, “Speech Communications: Human and Machine”, 2nd Ed., University Press, 2005.
5. Thomas F Quatieri, “Discrete-Time Speech Signal Processing – Principles and Practice”, 1st Ed., Pearson Education, 2006.
6. Gold, B., Morgan, N., & Ellis, D., “Speech and audio signal processing: processing and perception of speech and music” John Wiley & Sons, 2nd ED., 2011.

M.Tech. I (VL/CS) Semester – I VLSI LAB – II ECVL106	Scheme	L	T	P	Credit
		0	0	6	03

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Understand of Analog VLSI Circuits, VLSI Systems and Real-time systems through simulations
CO2	Implementation of various modules and sub modules of Analog VLSI Circuits, VLSI Systems and Real-time system
CO3	Analysis the of Analog VLSI Circuits, VLSI Systems and Real-time system
CO4	Evaluate the performance of Analog VLSI Circuits, VLSI Systems and Real-time system
CO5	Design of Analog VLSI Circuits, VLSI Systems and Real-time system for the given parameters

Analog VLSI Design

Following experiments are to be performed but not limited to:

1 Obtain various V-I characteristics of PMOS and NMOS transistor.

2 Design and simulate single stage CS amplifier with different load

3 Design and simulate single stage CG and CD amplifier with different load

4 Design & Simulate following current mirrors topologies.

5 Simulate and evaluate CS amplifier with feedback.

6 Design and Simulate Cascode amplifier with following specifications:

7 Characterize and evaluate Differential amplifier with resistive load.

8 Realize 3-bit Charge Scaling DAC and find output voltage for all input combinations.

9 Design 4-bit R-2R ladder DAC using active and passive switches

10 Design and Simulate Differential amplifier with current mirror load for given specifications.

11 Design of uncompensated single stage telescopic opamp.

12 Realize and evaluate folded cascade opamp

VLSI System Design:

1. Introduction of IP Integrator. Implement the trigonometric function using CORDIC IP
2. Design and Simulate following using IP
   a) Single MAC , b) Parallel MAC, c) Serial MAC
3. Design and Implement Low Pass FIR filter
4. Debugging MAC unit in hardware using ILA core and viewing ILA probe data in the waveform viewer.
5. RTL 2 GDSII (Standard Cell based Semi custom ASIC Flow)

- To study Logic synthesis:
  Using standard cell library and analysis of area, power, delay report. To obtain the design constraint file, LEC (Logic Equivalence Check), DFT (Design For Testability) insertion to verify the chip after fabrication, Gate-level netlist generation

- To study Place and Route (PnR):
  To place all the standard cells, Macros and I/O pads with minimal area, with minimal delay and Route based on Gate-level netlist, Floor Plan, Power Plan, Placement, CTS (Clock Tree Synthesis), and Routing , DRC (Design Rule Check) error, GDS-II file generation

- Signoff or Tapout : To fix the timing violations by post route simulation and a final layout file free from all the violations is streamed out in GDSII format

6. **Topics for Mini Projects:**
   Radix-4 Booth Multiplier, Parallel prefix adders, UART Hardware, I2C transceiver hardware, Divider, Square Root, CORDIC arithmetic, Control unit design for CPU Data path

Real Time System:

1 Write a code to create 5 threads with the pthread_create() routine.

2 Write a code to pass a simple integer to each thread.

3 Write a code to measure the time taken by each thread.

4 Write a code to set up/pass multiple arguments via a structure.

5 Write a program has different amplitudes at different carrier frequencies and phases.

6 Write a code to measure the time taken by each thread using sleep and without using sleep

7 Write a program that involves a reader and a writer thread with the help of mutex and semaphore.

8 Write a program to make an authentication system by using mutex and semaphore.

9 Calculate the different amplitudes at different digital values .

10 Write a program for blinking RGB LEDs by putting delay in between.

11 Write a program to print hello world by using a task.

12 Write a program to print hello world by five different tasks.

13 Write a program to print blinking of LEDs by using a task.

14 Write a program to implement DAC by using different tasks.

M.Tech. II (VL/CS) Semester – III DISSERTATION PHASE - I ECVL201	Scheme	L	T	P	Credit
		0	0	28	14

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Identify any latest topic of interest from the real-world technical problems to develop a thought process for design solution with basic understanding.
CO2	Extract a detailed literature survey related to the given problem and Apply the concepts for the solution to the given problem in terms of specification, design, component selection etc.
CO3	Synthesize or Implement the model/prototype of the project.
CO4	Write the well-organized report with compiled results and comprehension with proficiency in English.
CO5	Develop the effective and innovative presentation using modern tools/software

M.Tech. II (VL/CS) Semester – IV DISSERTATION PHASE - II ECVL202	Scheme	L	T	P	Credit
		0	0	40	20

1.	**Course Outcomes (COs):** At the end of the course, the students will be able to
CO1	Implement the proposed work with hardware /software resources and analyse results.
CO2	Compare the existing techniques and methods with proposed work.
CO3	Evaluate the results in terms of the performance parameters and further optimize the work for better solution.
CO4	Write the well-organized report with implemented results and comprehension with proficiency in English.
CO5	Attain the skills to solve real world problem in relevant area

DEPARTMENT OF
MECHANICAL ENGINEERING

M.TECH. (THERMAL SYSTEMS DESIGN)

SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY
Ichchhanath, Surat-395007, Gujarat, India
www.svnit.ac.in

MISSION & VISION STATEMENT OF INSTITUTE

Vision statement

To be one of the leading technical institutes disseminating globally acceptable education, practical industrial training, and relevant research output.

Mission statement

To be a globally accepted centre of excellence in technical education catalysing absorption, innovation, diffusion, and transfer of high technologies resulting in enhanced quality for all the stakeholders.

MISSION & VISION STATEMENT OF THE DEPARTMENT

Vision statement

Department of Mechanical Engineering, Sardar Vallabhbhai National Institute of Technology, Surat perceived to be a globally accepted centre of quality technical education based on innovation and academic excellence.

Mission statement

Department of Mechanical Engineering, Sardar Vallabhbhai National Institute of Technology, Surat, strives to disseminate technical knowledge to its undergraduate, postgraduate, and research scholars to meet the intellectual, ethical, and career challenges for sustainable growth of humanity, nation, and global community.

Programme Educational Objectives (PEOs)

Master of Technology in Thermal System Design imbibes in students' excellent technical capabilities in thermal engineering and allied systems, practical communication skills, ensuring successful careers, and continuing their professional advancement through life-long learning.

The program educational objectives of the Master of Technology in Thermal System Design

PEO1: Help students to achieve analytical, computational, and experimental skills for solving thermal-engineering-related problems.

PEO2: Have a high level of technical competency combined with research and problem-solving ability to generate innovative solutions in thermal engineering or related areas.

PEO3: Enjoy a successful career in industry and academia with an ethic for lifelong learning.

PEO4: Graduates will have inculcated to maintain high professionalism and ethical standards, effective technical presentation, and writing skills, and to work as a team on research projects.

Programme Outcomes (POs)

The graduates of M. Tech. (Thermal System Design) will demonstrate an ability to:

PO1	Carry out independent research /investigation and development work to solve practical problems
PO2	Write and express a substantial technical report/document
PO3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PSO1:	Design, analyse and solve thermo-fluid problems using modern tools and techniques.
PSO2:	Formulate and devise innovative and sustainable solutions to thermal engineering and allied problems.

Teaching Scheme M. Tech.-I (Thermal System Design)

Semester-I

Sr. No.	Subject	Code	Scheme L-T-P	Exam Scheme Th. Marks	T Marks	P Marks	Credits (Min.)	Notional hours of Learning (Approx.)
1	**Core Subject-1** Numerical Methods and Computations	METD101	3-1-0	100	25	0	4	70
2	**Core Subject-2** Advanced Thermodynamics	METD103	3-1-0	100	25	0	4	70
3	**Core Subject-3** Transport Phenomena - I	METD105	3-1-0	100	25	0	4	70
4	**Core Elective – 1** 1. Design of Refrigeration and Air-conditioning systems 2. Bio-Mass Conversion Systems 3. Electro-Chemical Energy storage systems 4. Environmental Pollution and Control 5. Gas Dynamics and Compressible Fluid Flow	METD111 METD113 METD115 METD117 METD119	3-0-0	100	0	0	3	55
5	**Core Elective – 2** 1. Electric Vehicles and Advanced IC Engines 2. Jet and Rocket Propulsion 3. Analysis and Design of Thermal Turbo Machines 4. Measurements and Data Analysis 5. Finite Element Method in Thermal Systems	METD121 METD123 METD125 METD127 METD129	3-0-0	100	0	0	3	55
6	Computational and Experimental Laboratory-I	METD107	0-0-6	0	0	150	3	110
						Total	**21**	**430**
7	Vocational Training/ Professional Experience/ Research Internship *(Optional)(Only for PG Diploma in TSD/Exit)*	METMV01 METMP01	0-0-10				5	200

Semester-II

Sr. No.	Subject	Code	Scheme L-T-P	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
				Th. Marks	T Marks	P Marks		
1	**Core Subject-4** Transport Phenomena – II	METD102	3-1-0	100	25	0	4	70
2	**Core Subject-5** Energy Conversion Systems	METD104	3-1-0	100	25	0	4	70
3	**Core Elective – 3** 1. Design of Heat Exchangers 2. Theory and Design of Cryogenic Systems 3. Combustion for Propulsion Systems 4. Biofluidic and Bioheat Transfer 5. Nanofluid and its applications in Thermal Systems	METD132 METD134 METD136 METD138 METD140	3-0-0	100	0	0	3	55
4	**Core Elective – 4** 1. Machine Learning for Thermal Systems 2. Flow and Flame Diagnostics 3. Transport in Porous Media 4. Renewable Energy Systems 5. Design of Solar Thermal System	METD142 METD144 METD146 METD148 METD150	3-0-0	100	0	0	3	55
5	**Institute Elective** 1. Computational Fluid Dynamics 2. Fundamentals of Electric Vehicles 3. Energy Conservation, Management, and Audit 4. Optimization Techniques 5. Turbulence and Turbulent Flows	METD172 METD174 METD176 METD178 METD180	3-0-0	100	0	0	3	55
6	Mini Project	METD106	0-0-4			100	2	70
7	Computational and Experimental Laboratory-II	METD108	0-0-6	0	0	150	3	110
						Total	**22**	**485**
8	Vocational Training/ Professional Experience/ Research Internship *(Optional) (Only for PG Diploma in TSD/Exit)*	METMV02 METMP02	0-0-10				5	200

Semester-III

Third Semester							
MOOC Course-I*						3/4	70/80
MOOC Course-II*						3/4	70/80
Dissertation Preliminaries	METD295	-	-	-	350$	14	560
					Total	**20-22**	**700-720**

***** Students may choose any available MOOC courses from SWAYAM/NPTEL with the consent of their M.Tech. supervisor

Semester-IV

Fourth Semester							
Dissertation	METD296	-	-	-	600$	20	800

Total Credits: 21 + 22 + 20-22 + 20 = 83-85 credits

Credit Matrix

Category	Credit to be earned				
	Sem - I	Sem – II	Sem – III	Sem – IV	Total
Core Courses	12	08	-	-	20
Elective Courses	06	09	-	-	15
MOOC Courses	-	-	6-8	-	6-8
Software/Laboratory	03	03	-	-	06
Mini Project	-	02	-	-	02
Dissertation	-	-	14	20	34
Total Credits	21	22	20-22	20	**83-85**

METD101	:	NUMERICAL METHODS AND COMPUTATIONS	L	T	P	Credits
			3	1	0	04

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Understand the fundamental of numerical methods and applications in engineering problems
CO2	Implement solution procedures for solving linear and non-linear algebraic equations
CO3	Learn how to solve definite integrals using cubic spline, Romberg and initial value problems, and boundary value problems numerically.
CO4	Solve ordinary differential equations (odes) and partial differential equations (PDEs) on a computer.
CO5	Acquire working knowledge of computational complexity, accuracy, stability, and errors in solution procedures
CO6	Solve one-dimensional optimization problems using the Golden Section Search method

2. Syllabus:

INTRODUCTION	**(03 Hours)**
Introduction to Computer-Aided Engineering Analysis, Measuring Errors, Sources of Error, Binary Representation of Numbers, Floating-Point Representation, Propagation of Errors, Taylor Theorem Revisit	
DIFFERENTIATION	**(04 Hours)**
Primer on Differential Calculus, Differentiation of Continuous Functions, Differentiation of Discrete Functions	
NONLINEAR EQUATIONS	**(04 Hours)**
Solving Quadratic Equations Exactly, Solving Cubic Equations Exactly, Bisection Method, Newton-Raphson Method, Secant Method, False-Position Method	
SIMULTANEOUS LINEAR EQUATIONS	**(05 Hours)**
Introduction to Matrix Algebra, Systems of Equations, Gaussian Elimination, Gauss-Seidel Method, LU Decomposition, Gauss-Seidel Method, Adequacy of Solutions, Eigenvalues and Eigenvectors, Cholesky and LDLT Method	
INTERPOLATION	**(04 Hours)**
Background of Interpolation, Direct Method, Newton’s Divided Difference Method, Lagrange Method, Spline Method	
REGRESSION	**(04 Hours)**

Primer on Statistical Terminology, Introduction to Regression, Linear Regression, Nonlinear Regression, Adequacy of Regression Models	
INTEGRATION	**(05 Hours)**
Primer on Integral Calculus, Trapezoidal Rule, Simpson's 1/3rd Rule, Romberg Integration, Gauss-Quadrature Rule, Discrete Data Integration, Improper Integration, Simpson's 3/8 Rule	
ORDINARY DIFFERENTIAL EQUATIONS	**(06 Hours)**
Primer on Ordinary Differential Equations, Initial Value Problems, Euler's Methods, Runge-Kutta methods, Predictor - Corrector Method, Higher-Order/Coupled ODEs, Boundary Value Problems, Shooting Method, Finite Difference Method	
PARTIAL DIFFERENTIAL EQUATIONS	**(05 Hours)**
Introduction to Partial Differential Equations, Parabolic Partial Differential Equations, Elliptic Partial Differential Equations	
OPTIMIZATION	**(05 Hours)**
Golden Section Search Method, Newton's Method, Multidimensional Direct Search Method, Multidimensional Gradient Method, Simplex Method	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Numerical methods for engineers, by S.C. Chapra, and R.P. Canale, Mcgraw-hill, Ed. 7, 2015
2	Numerical Methods in Engineering & Science, by B.S. Grewal, Khanna Publication, Ed. 11, 2013.
3	Numerical Mathematics and Computing, by Ward Cheney and David Kincaid, Cengage, Ed. 7, 2013
4	Applied Numerical Analysis, by Curtis Gerald and Patrick Wheatley, Pearson Education India, Ed. 7, 2007.
5	Analysis of Numerical Methods, by E. Isaacson & H. B. Keller, Dover Publications, 1994

METD103	:	ADVANCED THERMODYNAMICS	L	T	P	Credits
			3	1	0	04

1. Course Outcomes (COs)

At the end of the course, the students will be able to:

CO1	Describe thermodynamics properties of pure fluids and mixtures
CO2	Illustrate kinetic theory of gases
CO3	Describe combustion characteristics and how these can be measured.
CO4	Examine of stability in thermodynamic systems
CO5	Relate about statistical thermodynamics.
CO6	Implement concepts of exergy analysis to various thermodynamic systems

2 Syllabus:

INTRODUCTION	(07 Hours)
Review the first and second law of thermodynamics, Carnot theory, Principle of increase of entropy, and Application of the entropy principle. Entropy Evaluation— Ideal gas, Incompressible fluids, Solids, Entropy during phase change, Entropy of a Mixture of Ideal gases- Gibbs-Dalton's Law, Reversible Path Method. Entropy balance equation for different thermodynamic systems. Maximum Entropy and Minimum Energy— Maxima and Minima Principles- Entropy maximum, Internal Energy minimum, Enthalpy minimum, Helmholtz Free Energy Minimum, Gibbs Free Energy Minimum. Gibbsian Thermodynamics— Classical Rationale for Postulatory approach, Legendre Transformation, Generalized Relation for all Work Modes, Thermodynamic Postulates for Simple Systems.	
KINETIC THEORY OF GASES	**(04 Hours)**
Introduction, basic assumption, molecular flux, equation of state for an ideal gas, collisions with a moving wall, principle of equipartition of energy, classical theory of specific heat capacity. Transport phenomena-intermolecular forces, The Van der Waals equation of state, collision cross-section, mean free path. Three Parameter Equations of State, Generalized Equation of State, Empirical Equations of State, State Equations for Liquids/ Solids.	
THERMODYNAMIC PROPERTIES OF PURE FLUIDS AND MIXTURES	**(07 Hours)**
Ideal Gas Properties, James Clark Maxwell Relations, Second Maxwell Relation, Third Maxwell Relation, Fourth Maxwell Relation, Generalized Relations, Evaluation of Thermodynamics Properties, Pfizer Effect, Kesler Equation of State and Kesler Tables, Fugacity, Vapor/Liquid Equilibrium Curve, Throttling Process. Thermodynamics Properties of Mixtures —Partial Molal Property – Introduction, generalized relations, Euler and Gibbs-Duhem Equations, Relationship between Molal and Pure Properties, Ideal Gas Mixture, Ideal solution, Fugacity, Molal Properties using Equations of State.	
PHASE EQUILIBRIUM FOR A MIXTURE AND STABILITY	**(06 Hours)**
Phase Equilibrium-Two and Multiphase systems and Gibbs phase rule. Simplified criteria for Phase Equilibrium, Pressure and Temperature Diagrams- Completely Miscible Mixtures, Immiscible Mixture, Dissolved Gases in liquids, Derivations from Raoult's Law. Types of	

equilibrium and stability, Stability Criteria, Mathematical Criterion for Stability multi-component and multi-phase systems, Application to Boiling and Condensation, Entropy Generation during irreversible transformation.	
STATISTICAL THERMODYNAMICS	**(05 Hours)**
Introduction, energy states and energy levels, macro and microscales, thermodynamic probability, B-E, F-D, M-D statistics, distribution function, partition energy, statistical interpretation of entropy, application of statistics to a gases-mono-atomic ideal gas.	
EXERGY ANALYSIS	**(16 Hours)**
Concepts of exergy, exergy applied to control region, classification of exergy forms, exergy concepts for a control region, physical exergy, chemical exergy, and exergy concepts for closed system analysis. Control mass analysis, control region analysis, pictorial representation of exergy balance, and exergy-based property diagrams. Exergy Analysis For Various Processes**—**Exergy analysis for Expansions process, Compression process, Heat transfer process, Mixing and Separation Process, Chemical process mainly combustion, Combustion process.Energy Analysis of Systems — Gas turbine plant, Thermal power plant, Cogeneration plant, Captive power plant, Combined cycle power plant, Refrigeration plant, Chemical plant, Linde air liquefaction plant, Heat exchanger.Exergy Analysis For Steam Power Plant**—**Introduction to steam power plant systems, balance equations of exergy, exergy values, process description, exergy efficiency, simplified process diagrams, exergy losses, environmental impact, and sustainability.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	A. Bejan, "Advanced Engineering Thermodynamics," 3rd edition, John Wiley and sons, 2006.
2	F.W.Sears and G. L. Salinger, "Thermodynamics, Kinetic Theory, and Statistical Thermodynamics," Narosa Publishing House, New Delhi, 3rd edition, 1998
3	M.J.Moran and H.N.Shapiro, "Fundamentals Of Engineering Thermodynamics," John Wiley and Sons
4	M. W. Zemansky and R. H. Dittman, "Heat and Thermodynamics" McGraw Hill International Editions, 7th edition, 2007
5	I. K. Puri and K. Annamalai, "Advanced Engineering Thermodynamics," CRC Press, 2001
6	Kotas T .J., "The Exergy Methods of Thermal Plant Analysis," 2nd Ed., Krieger Publ. Corp. U.S.A., 2000
7	Turner, W.C., (Ed.), "Energy Management Handbook," John Wiley & Sons, N.Y., 2002.
8	Ibrahim Dincer, Marc A. Rosen, "Exergy – Energy, Environment and Sustainable Development," Elsevier Publications, 2021

METD105	:	TRANSPORT PHENOMENA-I	L	T	P	Credits
			3	1	0	04

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Recall fundamentals of fluid dynamics and heat transfer.
CO2	Develop a mathematical model for fluid dynamics and heat conduction problems.
CO3	Extend modelling approach to turbulence and multiphase flow problem.
CO4	Classify various turbulent flow modelling approaches.
CO5	Evaluate multi-dimensional heat conduction problems.
CO6	Formulate a numerical heat conduction model and compare it with its analytical solution.

2. Syllabus:

MOMENTUM TRANSPORT	
GOVERNING EQUATIONS OF FLUID MOTION	**(16 Hours)**
Lagrangian and Eulerian description, Reynolds transport theorem, Integral and differential forms of governing equations: mass, momentum, and energy conservation equations, Cartesian Tensors, Stokes hypothesis for stress tensor, Navier-Stokes equations, Energy equation, Euler's equation, Bernoulli's Equation, Exact solutions of Navier-Stokes equations in the Cartesian and cylindrical domain, Flow between concentric rotating cylinders, Parallel flow of power-law fluids, Stratified flow of two fluids, modeling of multiphase flow.	
TURBULENCE AND TURBULENT FLOW MODELLING	**(07 Hours)**
Mechanism of turbulence, Kolmogorov scale, Kinetic energy of the mean flow and fluctuations, turbulent intensity, Reynolds Averaged Navier-Stokes (RANS) equations, Turbulent stresses, Eddy viscosity, Prandtl mixing length model, K-Epsilon model of turbulence, Universal velocity distribution law and friction factor, Laminar–turbulent boundary layer transition, Turbulent boundary layers, Concept of Large Eddy Simulations (LES) and Direct Numerical simulations (DNS).	
DIFFUSION TRANSPORT BY HEAT	
INTRODUCTION TO STEADY-STATE AND UNSTEADY-STATE CONDUCTION	**(10 Hours)**
Introduction to three modes of heat transfer- conduction, convection, and radiation, Fourier's law of heat conduction in cartesian, cylindrical, and spherical systems, heat conduction in Isotropic and anisotropic material, various boundary conditions, Fixed and moving Fin heat transfer, Concept of fin efficiency and fin effectiveness, heat conduction in the porous medium, Concept of Biot number, Lumped system transients, 1-D transient problems-	

distributed system, Multidimensional transient problem-Heisler charts, Semi-infinite solid solution, Penetration depth	
MULTI-DIMENSIONAL STEADY-STATE CONDUCTION AND PHASE CHANGE PROBLEMS	**(06 Hours)**
Laplace equation, Solution by variable separable method, Concept of superposition and homogeneous boundary conditions, Phase change problems, Stefan and Neumann problems, analytical solutions	
NUMERICAL SOLUTION TO HEAT CONDUCTION PROBLEMS	**(06 Hours)**
Basic ideas of finite difference method, Forward, backward, and central differences, uniform and non-uniform grid, Discretization for the steady and unsteady heat equation with and without heat generation, 1-D and 2-D heat conduction in cartesian and cylindrical system	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Transport Phenomena in Multiphase Flows, Roberto Mauri, Springer Publication, 2015
2	Fluid Mechanics, Frank M. White, McGraw Hill Publications, 2016
3	Heat Conduction, D.W. Hahn, M.N. Özişik, John Wiley & Sons, Inc., 2012
4	Heat Conduction, L.M. Jiji, Springer Science & Business Media, 2009
5	Heat Transfer, P. S. Ghoshdastidar, Oxford University Press, 2012

METD111	**:**	**DESIGN OF REFRIGERATION AND AIR CONDITIONING SYSTEMS**	**L**	**T**	**P**	**Credits**
			3	**0**	**0**	**03**

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Describe the properties of refrigerants and evaluate the performance of the actual vapor compression refrigeration systems.
CO2	Evaluate the performance of compound vapor compression refrigeration systems for various applications.
CO3	Describe the vapor absorption system for large cooling load applications and evaluate its performance.
CO4	Explain the working principles of non-conventional refrigeration systems and evaluate the performance of steam jet refrigeration systems.
CO5	Compute cooling/heating loads for designing air conditioning systems for residential and commercial buildings.
CO6	Design the air duct systems for large commercial buildings.

2. Syllabus:

VAPOUR COMPRESSION REFRIGERATION SYSTEM	**(16 Hours)**
Alternate Refrigerants – properties, applications, selection, mixed refrigerants, retrofit study, standard rating cycle for domestic refrigerator, refrigeration system components: compressors, condensers, expansion devices, evaporators, Multi stage compression with water intercooler, liquid sub-cooler, flash chamber, flash intercoolers and multiple expansion valves, multi evaporator systems, cascade refrigeration system, Design aspects of refrigeration system components, solid CO2 – dry ice cycle.	
VAPOUR ABSORPTION SYSTEMS	**(06 Hours)**
Temperature concentration and enthalpy concentration diagrams, enthalpy balance for various components of aqua ammonia systems, Vapour absorption system- Electrolux refrigerator	
NON - CONVENTIONAL REFRIGERATION SYSTEMS	**(07 Hours)**
Steam jet refrigeration system, Performance analysis of steam jet refrigeration system, thermos electric refrigeration system, vortex tube Refrigeration, pulse tube refrigeration, adiabatic demagnetization, vapor adsorption refrigeration system	
AIR CONDITIONING	**(16 Hours)**
Review of air conditioning processes, summer and winter load calculations, cooling/heating load calculations, cooling coils, bypass factor, effective sensible heat factor, design consideration for cooling coils, high latent heat load, design of the evaporative cooling system, de-humidifiers and air washers, Comfort air conditioning, thermodynamics of human body, comfort charts, effective temperature, central air conditioning system, air	

handling unit, room air distributions, fluid flow, and pressure losses, air filters, duct design Equal pressure drop method, velocity reduction method, static regain method, refrigeration, and air conditioning controls

(Total Lecture Hours: 45)

3. Books Recommended:

1	Stocker, W. F., and Jones, J. W., “Refrigeration and Air Conditioning,” McGraw Hill, N. Y. 1986
2	Dossat, R. J., “Principles of Refrigeration,” John Wiley and Sons, 1988
3	Threlkeld, J.L., “Thermal Environmental Engineering,” Prentice-Hall, N. Y., 1970
4	Baron, R. F., “Cryogenics Systems,” Oxford Press, USA, 1985.
5	ASHRAE Fundamentals, Applications, Systems, and Equipment, 1999

METD113	:	BIOMASS CONVERSION SYSTEMS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Discuss biomass resources
CO2	Explain various biomass conversion routes
CO3	Model basic biomass conversion systems
CO4	Solve problems related to thermo-chemical routes of biomass conversion
CO5	Explain the concept of sustainability and resilience.
CO6	Apply the knowledge to deal with complex problems

2. Syllabus:

INTRODUCTION	**(06 Hours)**
Biopower, Bioheat, Biofuels, advanced liquid fuels, drop-in fuels - Biobased products.	
BIOMASS FEEDSTOCKS	**(08 Hours)**
Harvested Feedstocks, Feedstocks for first-generation biofuels, Feedstocks for second-generation Biofuels, Feedstocks for third-generation feedstocks, Agricultural waste - Forestry waste - Farm waste - Organic components of residential, commercial, institutional, and industrial waste.	
BIOMASS CONVERSION TECHNOLOGIES	**(09 Hours)**
Biorefinery Concept, understanding biorefinery concept, Biorefineries& end products, Hydrolysis, enzyme & acid hydrolysis, Fermentation, Anaerobic digestion, Trans-esterification, Combustion, Gasification, Pyrolysis, Other thermochemical conversion technologies, Scaling up emerging technologies.	
SUSTAINABILITY & RESILIENCE	**(10 Hours)**
Understanding sustainability, Environmental sustainability, Bioenergy & sustainability, Bioenergy & Environment, Criteria Pollutants, Carbon Footprint, Emissions of biomass to power generation applications, Emissions from biofuels, Indirect land-use change (ILUC) issues.	
LIFE CYCLE ANALYSIS	**(12 Hours)**
General understanding of LCA, Cradle-to-grave, field-to-wheels concepts, Goal and scope determination, defining LCA boundaries, Life Cycle Inventory, Advanced low-carbon fuels from waste, Advanced low-carbon fuels, and Case study.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Biomass-Application, technology & production, N.C. Cheremisinoff, P.N. Cheremisinoff & F. Ellurbrush, Marcel Dekker, New York, 1980
2	Biomass for Renewable Energy, Fuels, and Chemicals, Donald L. Klass, Reed, Academic Press, Elsevier, 1998
3	Bio-fuels: biotechnology, chemistry, and sustainable development by DM Mousdale, CRC Press, 2008
4	Renewable Energy by B Sorensen, Academic Press, New York, 2002
5	Renewable energy: Power for a sustainable future by G Boyle (Ed), Oxford, 1996

METD115	:	ELECTRO-CHEMICAL ENERGY STORAGE SYSTEMS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Illustrate the basic principle of electro chemical cell
CO2	Examine circuit models in electrochemical cells
CO3	Apply the thermodynamic model of fuel cells and batteries to solving complex problems
CO4	Evaluate the chemical kinetics of electrochemical reactions
CO5	Apply the concept of transport phenomena in electrochemical cells.
CO6	Analyse the transport phenomena in electrochemical cells

2. Syllabus:

INTRODUCTION	**(08 Hours)**
Basic Physics of Galvanic cell, Electro chemical energy conversion, Electro-Chemical Energy Storage	
CIRCUIT MODELS	**(05 Hours)**
Dynamics of Equivalent Circuits, Impedance spectroscopy, Impedance of Electrode	
THERMODYNAMICS	**(08 Hours)**
Statistical Thermodynamics, The Nernst Equation, Fuel Cells, and Lead-Acid Batteries, Li-ion batteries, Pseudo-capacitors, and Batteries, Reconstitution Electrodes	
KINETICS	**(12 Hours)**
Reactions in Concentrated Solutions, Theory of Chemical Kinetics and Charge Transfer Based on Non-equilibrium Thermodynamics, Butler-Volmer Equation, Electro-catalysis, Electro-Chemical Phase transformation, Homogeneous charge transfer, Charge Transfer at the metal electrode	
TRANSPORT PHENOMENA	**(12 Hours)**
Concentration Polarization, Transient Diffusion, Warburg Impedance, Boundary Layer Analysis of Electrochemical Cells, Forced convection in a fuel cell, Theory of Chemical Kinetics and Charge Transfer Based on Non-equilibrium Thermodynamics., Transport in Bulk Electrolytes, Homogeneous Reaction-diffusion, Transport in Bulk Electrolytes, Ion Concentration Polarization, Diffuse Charge in Electrolyte, Diffuse Double Layer Structure, Transport in porous media, Scaling analysis of energy storage, Porous electrode	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Newman, John and Karen E. Thomas-Alyea. Electrochemical systems. 3rd ed. Wiley-Interscience, 2004
2	O' Hayre, Ryan, Suk-Won Cha. Fuel Cell Fundamentals. 2nd ed. Wiley, 2009
3	Huggins, Robert A. Advanced batteries: Materials Science Aspects. Springer, 2008
4	Bard, Allen J., and Larry R. Faulkner. Electrochemical Methods: Fundamentals and Applications. 2nd ed. Wiley, 2000

METD117	:	ENVIRONMENTAL POLLUTION AND CONTROL	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Evaluate the air pollution effect on human health and plant
CO2	Measure and characterize noise from the different sources such as construction, mining etc.
CO3	Explain waste and advanced water treatment.
CO4	Show Handling of toxic and radioactive wastes Incineration and verification.
CO5	Create concrete solutions to minimize the air, water, land, and noise pollution.
CO6	Explain the norms, rules, and regulations of air, water, land, and noise pollution

2. Syllabus

INTRODUCTION	**(02 Hours)**
AIR POLLUTION AND CONTROL	**(12 Hours)**
Air pollution; Air Pollution Effect on Plants; Air Pollution effect on Human health; Air quality monitoring; Air Pollution Meteorology; Gaussian Plume model; Urban Air Pollution; Air Pollution from Industries; Air Pollution Control; standards; norms; rules and regulations; Indoor Air Pollution.	
NOISE POLLUTION AND CONTROL	**(12 Hours)**
Sources of noise pollution – Properties and Measurements of Noise – Noise Propagation, Noise level meters – types, components, Noise Power level, Intensity level, Pressure level, Characteristics and Effects of noise – Characterization of Noise from Construction, Mining, Transportation and Industrial Activities, Airport Noise – General Control Measures – Effects of noise pollution – auditory effects, non-auditory effects	
WATER POLLUTION AND CONTROL	**(13 Hours)**
Water pollution – Sampling and analysis of waste treatment, Advanced wastewater treatments by physical, chemical, biological, and thermal methods, and Effluent quality standards. Solid waste management – Classification and their sources – Health hazards – Handling of toxic and radioactive wastes Incineration and verification	
OTHER SOURCES OF POLLUTION AND THEIR CONTROL	**(06 Hours)**
Pollution control in process industries, namely Cement, Paper. Petroleum and petrochemical, Fertilizers and distilleries, thermal power plants, and automobiles	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Manster, G.M., Introduction to Environmental Engineering and Science, 2nd ed., Pearson Publishers, 1991
2	Rao, E.S., Environmental Pollution Control Engineering, Wiley Eastern Ltd., 1991.
3	Mahajan, S.P., Pollution Control in Process Industries. Tata McGraw-Hill, 1985.
4	Crawford, M., Air Pollution Control Theory, TMH, 1976
5	Noise Pollution and Control Strategy, S.P. Singal -, Alpha Publishers, 2005

METD119	:	GAS DYNAMICS AND COMPRESSIBLE FLUID FLOW	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (Cos):

At the end of the course, the students will be able to:

CO1	Predict the effect of compressibility and flow behavior in the field of gas dynamics
CO2	Solve 1-D design problems based on Isentropic, Fanno, and Rayleigh flow
CO3	Evaluate the different possible conditions for flow without choking in a 1-D duct with the variable area, friction, and heat transfer.
CO4	Identify the position and effect of shock within the 1-D duct and learn to use the polar shock diagram for 2-D flows.
CO5	Explain the method of Characteristics for Nozzles
CO6	Evaluate Gas Dynamics of wet steam

2. Syllabus:

ONE-DIMENSIONAL COMPRESSIBLE FLOW	(12 Hours)
One dimensional flow concept, Isentropic flows, Stagnation/Total conditions, Characteristics speeds of gas dynamics, Dynamic pressure and pressure coefficients, Normal shock waves, Rankine-Hugonoit equations, Rayleigh flow, Fanno flow, Crocco's theorem, isentropic flow through the converging nozzle, the influence of friction on flow through the nozzle, supersonic nozzle, moving shocks, the combined effect of area changes, head addition, and friction in the nozzle.	
TWO-DIMENSIONAL FLOWS	**(12 Hours)**
Oblique shock wave and its governing equations, θ-B-M relations, The Hodograph and Shock Polar, Supersonic flow over wedges Mach line, Attached and Detached shock, Reflections, and interaction of oblique shock waves, Mach Reflection, Expansion waves, Prandtl-Meyer flow and its governing equations, Supersonic flow over convex and concave corners, Approximation of continuous expansion waves by discrete waves.	
METHOD OF CHARACTERISTICS	**(11 Hours)**
Concepts of Characteristic, Compatibility Relation, Theorems for Two-Dimensional Flow, characteristics and their association with Riemann Invariants, elements and their approximations by weak waves, Design of Supersonic Nozzle.	
GAS DYNAMICS OF WET STEAM	**(10 Hours)**
Clausius-Clapeyron equation, adiabatic exponent, conservation equations for wet steam, relaxation times, sound speed, an overview of relaxation zones, combined relaxation, flow in variable area nozzle, shocks in wet steam, condensation shock, and jump conditions.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Rathakrishnan, Ethirajan. “Applied gas dynamics.” Wiley, (2019)
2	Somasundaram S.L., “Gas Dynamics & Jet Propulsion,” New Age International (P) Ltd., New Delhi, 1996
3	Zucker, Robert D., and Oscar Biblarz. Fundamentals of gas dynamics. John Wiley & Sons, 2019
4	Aerothermodynamics and flow in turbomachines Vavra, M.H., John Wiley 1960
5	The dynamics and thermodynamics of compressible fluids, Vol. I & II, Shapiro A.H., Ronald Press, 1965
6	A mathematical theory of compressible fluid flow – Richard Von Mosses – Academia Press. N.Y., 1958
7	B. Lakshminarayana. “Fluid dynamics and heat transfer of turbomachinery.” John Wiley & Sons; 1995
8	Korpela, S. A., “Principles of turbomachinery,” 2nd Edition, Wiley and Sons, 2019
9	Ronald D. Flack, “Fundamentals of Jet Propulsion with Application,” Cambridge University Press, 2005
10	Ruey-Hung Chen, “Foundations of Gas Dynamics,” CAM Press, 2017

METD121	:	ELECTRIC VEHICLES AND ADVANCED I C ENGINES	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (Cos):

CO1	Compare the general specifications of various commercially available vehicle
CO2	Apply material and design considerations for various engine components
CO3	Evaluate effects of various parameters including use of alternate fuels on normal and abnormal combustion, emission and performance in CI and SI Engines
CO4	Compare basic layout and structure of EV and I C Engines
CO5	Work out battery and motor sizing for various applications in two, three and four-wheeler segment
CO6	Analyse Bus Rapid Transit Systems

2. Syllabus:

INTRODUCTION TO I C ENGINES	**(03 Hours)**
Historical Perspective, General Specifications of Engines used in various Two, Three, and Four Wheelers. Air Standard Thermodynamic Cycles for I C Engines and its comparison with Fuel Air and Actual Cycle, Thermodynamic properties of the working fluid	
MATERIAL AND DESIGN CONSIDERATION FOR ENGINE COMPONENTS	**(04 Hours)**
Piston, Cylinder, Piston Rings, Connecting Rod, Cam Shafts, Crank Shafts, etc	
GAS EXCHANGE PROCESS	**(04 Hours)**
Flow-through valves, Analysis of suction, and Exhaust Processes	
COMBUSTION IN SI AND CI ENGINES	**(06 Hours)**
Combustion Phenomenon in SI and CI Engines, Normal and Abnormal combustion in SI and CI Engines, modelling combustion process in SI engines, Advanced mode combustion like HCCI, PCCI, AFCI, RCCI, etc	
ALTERNATE FUELLED ENGINES	**(03 Hours)**
Producer Gas, Biogas, and Biodiesel Fuelled Engines	
ENGINE EMISSION	**(06 Hours)**
Introduction to air pollution from SI and CI Engines, Photochemical smog, primary and secondary pollutants, Formation of NO and NO2 in SI and CI Engines, Mechanism of Particulate Matter formation, Composition of Particulates, soot structure, soot formation, Measurement of emission, instrumentation for HC, CO, NOx, and PM, EGR and Diesel Particulate Filter	
INTRODUCTION TO ELECTRIC VEHICLES	**(04 Hours)**

Limitations of Internal Combustion Engines as Prime Mover, History of EV and EV Systems, Structure of Electric Vehicle covering essential Components, General Layout, Govt. policies on EV and its impact on the automotive sector	
EV POWER TRAIN	**(12 Hours)**
Basic components like Battery, DC-AC Converters, Electric Motors, DC-DC Converters, Transmissions, and ECUs. Battery and Motor Selection, Calculations for Motor and battery sizing for EV for Two, Three, and Four Wheeler Applications, Thermal Management of Battery, Initial acceleration, rated vehicle velocity, maximum velocity, and maximum gradeability of EV, the Basic architecture of EV Drive Train.	
URBAN TRANSPORT	**(03 Hours)**
Urban Bus Specifications, Bus Rapid Transit Systems	

(Total Lecture Hours: 45)

3. <u>Books Recommended:</u>

1	The Science and Technology of Materials in Automotive Engine, Hiroshi Yamagata, CRC Press Inc
2	Internal Combustion Engines Fundamentals. John B Heywood. Mc Graw Hill (Indian Edition) 2017
3	Internal Combustion Engines by V Ganesan. 4th Edition. Tata Mc Graw Hill Edition
4	Modern Electric, Hybrid Electric, and Fuel Cell Vehicles. Mehrdad Ehsani, Yimin Gao, et al
5	Handbook of Electric Vehicles, Joseph Kent. Clanrye International. (2015)

METM123	:	JET AND ROCKET PROPULSION	L	T	P	Credits
			3	**0**	**0**	**03**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Illustrate various types of jet systems and understand difference between air breathing and non-air breathing engines.
CO2	Analyze the thermodynamics cycles and performance parameters of air breathing systems
CO3	Demonstrate rocket propulsion theory and discuss classifications of rockets
CO4	Illustrate rocket nozzle types and their flow behavior at design and off-design conditions.
CO5	Analyse the performance parameters of rocket propulsion systems
CO6	Explain types of chemical rockets and details of its propellant

2. Syllabus

INTRODUCTION	**(09 Hours)**
Introduction of gas turbine cycle and various components of gas turbine engine, Introduction of jet propulsion systems, Computation of stagnation properties, Basic components of air breathing engines, Inlet ducts for aircraft gas turbines, Brief idea about compressor, combustion chamber, turbine, and aircraft nozzles, Classification of propulsive device, types of rocket engines, application of rocket engines. Non-chemical rocket engines: Electric propulsion, Nuclear rocket engines, Solar Energy rockets.	
AIR BREATHING ENGINES	**(06 Hours)**
Performance parameters for air breathing engine (Thrust, Efficiency, Aircraft Range, Take-off Thrust, Specific Fuel Consumption), Basic gas generator & its variations, Turbojet, Turboprop, Turbofan, Pulse jet, Ram jet, Scramjet, Thrust Augmentation	
PARAMETRIC CYCLE ANALYSIS OF AIR BREATHING GAS TURBINE ENGINES	**(09 Hours)**
Parametric Cycle Analysis of Ideal Turbo Jet Engine, Real Turbojet Cycle, Analysis of Turbofan Engine, Analysis of Turbofan Engine, Analysis of Turboprop Engine, Ramjet & Scramjet Engine.	
ROCKET PERFORMANCE PARAMETERS	**(06 Hours)**
Laws of thermodynamics, combustion parameters, rudiments of gas dynamics, Ideal rocket performance, thrust equation, Total impulse and Specific Impulse, Specific impulse efficiency, volume specific impulse, impulse-to-weight ratio, energy balance, efficiencies and coefficients of rocket engines.	
NOZZLES FOR ROCKET ENGINES	**(03 Hours)**

Rocket nozzles; expansion of gases from high pressure chamber. Convergent divergent nozzle, choking and variation of parameters in nozzle. Expansion ratio of nozzles and performance loss in nozzles. Under-expanded and over-expanded nozzles. Losses and performance analysis of rocket engines.	
ROCKET PROPELLANTS AND ENGINES	**(12 Hours)**
Classification of Chemical propellants, Solid propellants, Liquid propellants, Gel Propellants and Hybrid Propellants. Solid-propellant rocket engines—Burning mechanism, Propellant Burning and regression rates, Propellant grain configuration, Ignition system. Liquid-propellant rocket engines—Classification of engines, Combustion of Liquid Propellants, Combustion chamber geometry, Ignition systems, cooling systems, Hybrid-propellant rocket engines— combustion chamber, grain configuration, Ignition of hybrid propellants	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Hill, P. G. and Peterson, C. R., "Mechanics and thermodynamics of propulsion" Wesley Publishing Company, USA, 1992
2	Mattingly, J. D., "Elements of gas turbine propulsion", Tata McGraw-Hill Edition, NY, USA, 2005
3	Jack D. Mattingly, "Elements of Propulsion: Gas Turbines and Rockets," AIAA Publication, USA, 2016
4	Sutton, G. P. and Biblarz O., "Rocket propulsion elements" Wiley Publications, USA, 2016
5	Mukunda H. S., "Understanding aerospace propulsion," Interline Publishing, Bengaluru, India, 2017

METD125	:	ANALYSIS AND DESIGN OF THERMAL TURBOMACHINES	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (Cos):

At the end of the course, the students will be able to:

CO1	Explain the working principles of turbomachines and apply them to various types of turbomachines
CO2	Design axial compressors and turbines.
CO3	Determine the off-design behavior of axial turbines and compressors
CO4	Design radial compressor and turbine
CO5	Establish performance characteristics curves of thermal turbomachines.
CO6	Assess & analyze the performance outcomes of thermal turbomachines.

2. Syllabus:

INTRODUCTION OF THERMAL TURBOMACHINES	(16 Hours)
Introduction - Turbomachines basics and classifications, Steam turbines - Types – Classification – constructional details of different types of steam turbines., Gas turbines – Types – Classification – Gas turbines engine and its components – constructional details of components – working principles of different components – Gas turbine power plant matching characteristics.	
COMPRESSORS	**(14 Hours)**
Centrifugal compressors – Components – Enthalpy-Entropy diagram -Energy transfer – Slip -Pressure coefficient -Isentropic efficiency – Effect of compressibility and pre-whirl - Diffuser – Nondimensional parameters – surging – choking – performance characteristics. Axial flow compressors – Components – Enthalpy-Entropy diagram – Velocity triangles - number and type of staging with characteristics – Air and blade angles – Degree of reaction – Losses – Radial equilibrium and actuator disc theory performance characteristics.	
TURBINES	**(15 Hours)**
Radial Turbines - Elements of radial turbine stages – Enthalpy-Entropy diagram – stage velocity triangles – stage losses – performance characteristics – outward flow radial stages.Axial Turbines -Impulse and Reaction- Velocity triangles -Turbine speed -Number of stages and stage work – Gas angles and blade angles. Losses in turbines – Reheat factor and condition curve -constant stage – efficiency – forms of actual condition curve – Turbine total wheel speed – Partial admission turbines – losses – Applications – performance estimation.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Theory and Design of Steam and Gas Turbines, Lee J.F., McGraw-Hill Book Company Inc., London, 1999
2	Steam turbines – Theory and Design, Shlyakhin. P., University Press of the Pacific, 2005
3	Gas Turbine Theory” H.I.H. Saravanamuttoo, Prof G.F.C. Rogers, H. Cohen, & P V Straznicky, 7th edition, Person publishers, 2017
4	Turbo Machine, Yahya S.M., 4th Edition, Tata McGraw Hill, 2011
5	Axial Flow Compressors, Fluid Mechanics and Thermodynamics, Horlock J. H. Butterworths Scientific Publications, 1958
6	Axial Flow Turbines: Fluid Mechanics and Thermodynamics, J. H. Horlock, Butterworths, 1966

METD127	**:**	**MEASUREMENTS AND DATA ANALYSIS**	**L**	**T**	**P**	**Credits**
			3	**0**	**0**	**03**

1. Course Outcomes (Cos):

At the end of the course, the students will be able to:

CO1	understand the knowledge of measurement systems and methods with emphasis on different transducers, intermediate modifying, and terminology devices.
CO2	examine the engineering sensors for different types of thermal systems.
CO3	analyze the measurement of force, torque, load, flow, pressure, temperature, and strain.
CO4	evaluate the concepts of errors in measurements, statistical analysis of data, regression analysis, correlation, and uncertainty estimation.
CO5	illustrate various process control principles, transfer functions, block diagrams, and signal flow graphs.
CO6	develop the concept of zero, first and second-order thermal systems.

2. Syllabus:

BASICS OF MEASUREMENT	**(08 Hours)**
Basic concepts of measurements, Different types of errors in measurements, Characteristics of measurement systems (calibration, sensitivity, and error analysis), Statistics in Measurements, Static and dynamic characteristics; System response- first and second-order systems and analysis, Uncertainty in measurements, Linear regression, Parity plot, Design of experiments: design of experiments based on sensitivity function and uncertainty analysis. Examples related to (a) determining the duration of the experiment and (b) choosing between steady-state and transient techniques.	
HEAT TRANSFER AND GAS TEMPERATURE MEASUREMENT	**(08 Hours)**
Overview of thermometry, thermoelectric temperature measurement, Different principles of Temperature Measurement, thermometers, 29hermos positive elements, thermocouples in series & parallel, Resistance thermometry, Pyrometer, calibration of temperature measuring instruments, issues in measurements Heat flux measurement, Interferometry, Differential Interferometer, Thermal conductivity measurement: Guarded hot plate apparatus, heat flux meter.	
MEASUREMENT OF FLOW PROPERTIES, FLOW VISUALIZATION	**(06 Hours)**
Different methods of incompressible and compressible obstruction flow measurements, Pitot static tube, Hot wire anemometer, Magneto and Ultrasonic flow measurements, Doppler effect, Vortex Shedding Flow meter, Laser Doppler velocity meter.	
PRESSURE, LOAD & STRAIN MEASUREMENT, TORQUE MEASUREMENT	**(07 Hours)**

Different pressure measurement instruments and their comparison, Transient response of pressure transducers, Measurement of vacuum, Electrical pressure transducers, force balance pressure gauges, Basics in the measurement of force, torque, and shaft power, Displacement measurements	
PROCESS CONTROL	**(08 Hours)**
Introduction and need for process control principles, transfer functions, block diagrams, signal flow graphs, open and closed-loop control systems – Analysis of First & Second-order systems with examples of mechanical and thermal systems. Control System Evaluation – Stability, steady-state regulations, and transient regulations.	
DATA ANALYSIS AND DATA ACQUISITION SYSTEMS	**(08 Hours)**
Data analysis & interpretation: Statistical analysis of experimental data- normal error distributions (confidence interval and level of significance, Chauvenet's criterion, Chi-square test of goodness of fit, method of least squares (regression analysis, correlation coefficient), multivariable regression, Students' t-distribution, graphical analysis, and curve fitting, data acquisition systems: analog input-output communication, analog to digital converter, the static and dynamic characteristic of signals, Bits, Transmitting digital numbers, resolution, quantization error, signal connections, single and differential connections, signal conditioning.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	E.O. Doblin, Measurement Systems, McGraw-Hill, New York, 1986
2	J.P. Holman, Experimental Methods for Engineers, McGraw-Hill Science Engineering; 8th Edition, 2011
3	T.G. Beckwith and N.L. Buck, Mechanical Measurements, Addison-Wesley, MA (USA), 1969
4	D.C. Montgomery, Design and Analysis of Experiments, John Wiley, New York, 2001
5	A.S. Morris, *Principles of Measurement and Instrumentation*, Prentice Hall of India, New Delhi, 1999
6	S. P. Venkateshan, Mechanical Measurements, John Wiley & Sons and Ane Books Pvt. Ltd., 2nd Edition, 2015
7	Nakra, B. C., and K. K. Chaudhry. Instrumentation, measurement, and analysis. Tata McGraw-Hill Education, 2003

METD129	:	FINITE ELEMENT METHOD IN THERMAL SYSTEMS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (Cos)

At the end of the course, the students will be able to:

CO1	Develop weighted residual methods
CO2	Classify the concepts of Nodes and elements
CO3	Apply finite element modelling techniques for 1-D problems.
CO4	Build finite element modelling techniques for 2-D problems.
CO5	Formulate and solve fluid and heat transfer problems using FEM
CO6	Extend the FEM to transient problems.

2. Syllabus

INTRODUCTION TO FINITE ELEMENT METHOD	(05 Hours)
General introduction to finite element method, Types of analysis methods, Boundary Information, Initial Value Problem, Boundary Value Problem, Numerical methods, Direct Finite Element Method, Minimum potential energy method, weighted residual method: Co-location method, Sub-domain method, Least-Square method, Galerkin method and Methods of moments.	
ONE-DIMENSIONALANALYSIS	**(12 Hours)**
Solution of second-order linear model boundary value problem: Discretisation of the domain, 1-D Iso-parametric element, weak form development, Lagrange interpolation functions: linear and quadratic, elemental response, Connectivity of elements, Assembly of elemental responses. Incorporation of boundary conditions, solution for unknown: elimination and penalty approach. Application to 1-D Heat Transfer: with and without heat generation and constant and variable cross-section. 1-D Fluid flow analysis.	
TWO DIMENSINAL ANALYSIS	**(10 Hours)**
Two-dimensional steady-state heat conduction equation, Triangular elements, development of elemental stiffness matrix and load vector, Assembly of elemental response. Solution of 2-D heat conduction problem with and without heat generation.	
DYNAMIC ANALYSIS	**(06 Hours)**
1-D transient heat conduction in pin-fin: derivation of the fundamental equation in matrix form, assembly of elements, solution using the trapezoidal rule. Stability Analysis. Solution of Transient temperature distribution along the length of the pin fin.	
COUPLED BOUNDARY VALUE PROBLEMS: HEAT TRANSFER AND FLUID MECHANICS	**(12 hours)**
Convection Heat Transfer, Governing Equations, Non-Dimensional Form of Governing Equations, Convection-diffusion problem, Finite element solution to the steady and transient	

convection-diffusion problem: Laminar heat transfer, Forced convection, Buoyancy-driven convective heat transfer, and mixed convection.

(Total Lecture Hours: 45)

3. Books Recommended:

1	Logan D. L., A first course in the finite element method, Cengage Learning, 2012.
2	J. N. Reddy and D. K. Gartling, Finite Element Method in Heat Transfer and Fluid Dynamics, CPC press Third Edition, 2010
3	P. Seshu, Finite Element Analysis, PHI learning Pvt. Ltd., New Delhi, 2012
4	Fagan M. Finite Element Analysis. Theory and Practice, Pearson Education Limited, UK, 1992
5	Roland W. Lewis, PerumalNithiarasu and Kankanhalli N. Seetharamu, Fundamentals of the Finite Element Method for Heat and Fluid Flow, Wiley, July 2004

METD107	:	COMPUTATIONAL AND EXPERIMENTAL LABORATORY -I	L	T	P	Credits
			0	0	6	03

1. Course Outcomes (COs)

CO1	Develop numerical solutions, linear, non-linear algebraic equations, initial value problems and boundary value problems using computer programs
CO2	Derive numerical solutions to initial value problems and boundary value problems
CO3	Develop code to solve ordinary differential equations (ODEs), and partial differential equations (PDEs), and optimization problems.
CO4	Understand and demonstrate the operation of identified system/ instrument/ equipment
CO5	Perform given practical task independently on system/instrument/equipment
CO6	Analyse and evaluate the observations and deduce conclusions therein

COMPUTATIONAL LAB

SOFTWARE
1. Introduction to open source and commercial software
CODING
1. Introduction to compiler, scripts, loops, logical statements 2. Finding roots using the Bisection method 3. Discovering roots using the Newton-Rapson method 4. Solving ODE using the Rung-Kutta method of 2nd order: Heun's method, Mid-point method, and Ralston's method 5. Solving ODE using the Rung-Kutta method of 3rd order, and 4th order 6. Development of steady-state solver: (a) TDMA/ Line-by-line TDMA (b) Point-Jacobi (c) Gauss-Seidel Method (d) Gauss-Seidel over-relaxation Method 7. Development of transient solver: (a) Euler or Explicit scheme (b) Pure implicit scheme (c) Crank-Nicolson scheme (d) ADI 8. FDM code to solve PDE: elliptic equation 9. FDM code to solve PDE: parabolic equation 10. FDM code to solve PDE: hyperbolic equation

EXPERIMENTAL Lab

(Any 10 experiments)

1. Calibration of thermocouple
2. Thermal conductivity of insulating powder
3. Heat transfer through composite wall
4. Heat transfer from pin fin apparatus
5. Emissivity measurement
6. Radiation exp-2 (Thermal imaging camera)

7. Performance test on vapor compression refrigeration system
8. Performance test on vapor absorption system.
9. Performance test on Ice plant
10. Performance test on air conditioning plant
11. Performance test on Cascade Refrigeration system
12. Performance test of 4-stroke Petrol Engine.
13. Performance test of 4-stroke Diesel Engine.
14. Heat Balance Preparation for 4-stroke Diesel Engine.
15. Heat Balance Preparation for four-stroke Petrol Engine
16. Determination of friction power of multi-cylinder petrol engine using Morse Test Method.
17. Determination of friction power of single/multi-cylinder petrol engine using Willan's Line Method.
18. Demonstration of wind tunnel
19. Demonstration of thermal turbomachines
20. Performance on a nozzle test rig
21. Junker's gas calorimeter
22. Bomb's calorimeter
23. Redwood viscometer
24. Gas chromatography
25. Heat pipe experiments
26. Pulsating heat pipe experiments
27. Thermosyphon experiments
28. Microchannel heat sink experiment
29. PCM based experiment-1
30. PCM with extended surface experiment-2
31. Combustion flame and analysis experiments
32. Vortex tube refrigeration
33. Liquid nitrogen plant demonstration
34. Pulse tube refrigeration system
35. Two-phase flow experiments
36. Fluid dynamics experiment-1
37. Fluid dynamics experiment-2
38. Automobile demonstration and experiment
39. Free convection experiment
40. Forced convection experiment
41. Heat exchanger experiment-1
42. Heat exchanger experiment-2
43. Measurement experiment-1
44. Measurement experiment-2
45. Calibration of various instruments

METD102	:	TRANSPORT PHENOMENA-II	L	T	P	Credits
			3	1	0	04

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Recall fundamentals of convective heat transfer mode.
CO2	Develop mathematical models for forced and natural convection problems.
CO3	Extend modelling approach to two-phase flow problem.
CO4	Analyse radiative heat transfer between black and actual surfaces
CO5	Evaluate radiation heat transfer solution in participating medium
CO6	Combine the analogy between momentum, heat, and mass transfer.

2. Syllabus:

ENERGY TRANSPORT BY CONVECTION	
FORCED CONVECTION HEAT TRANSFER	**(12 Hours)**
The physical mechanism of convection, thermal boundary layer, heat transfer in turbulent flow, solution of convection equations for a flat plate, nondimensional convection equations and similarities, functional forms of friction and convection coefficients, analogies between momentum and heat transfer, drag and heat transfer in external flow, parallel flow over flat plates, flow across cylinders and spheres, flow across tube banks, average velocity and temperature, the entrance region, general thermal analysis, laminar and turbulent flow in tubes (circular and non-circular), transitional flow in tubes	
NATURAL CONVECTION HEAT TRANSFER	**(06 Hours)**
The physical mechanism of natural convection, equation of motion and the Grashof number, natural convection over surfaces, natural convection over finned surfaces and PCBs, natural convection inside enclosures, combined natural and forced convection	
MOMENTUM AND ENERGY TRANSPORT IN TWO-PHASE FLOW	**(07 Hours)**
Introduction, flow regimes, and maps, Homogeneous model, separated flow model, drift flux model, two-phase Pressure drop modeling, Boiling heat transfer, pool boiling, flow boiling, Condensation heat transfer, film condensation, dropwise condensation, application of Reynold’s analogy to non-boiling two-phase flow	
ENERGY TRANSPORT BY RADIATION	
THERMAL RADIATION	**(06 Hours)**
Black body radiation, radiation intensity, radiative properties, solar heat gains through windows, need for view factors, Concept of view factors, Mathematical definition, View factor Algebra, Hotel’s crossed string method, View factors for 2D surfaces using algebra, View factors from 2D surfaces using charts. Enclosure analysis, Radiosity Irradiation method for Gray diffuse enclosures, 2 and 3 surface enclosures, Radiation shields, Concept of re-radiating surface	

GAS RADIATION	(06 Hours)
Introduction to gas radiation – The equation of transfer – Simple derivation solutions to the equation of transfer, Concept of mean beam length – Calculation of mean beam length for simple geometries from charts and formula, Engineering treatment of gas radiation in enclosures – modified enclosure theory – problems to illustrate the modified enclosure theory, heat transfer from the human body	
DIFFUSION TRANSPORT BY MASS	**(08 Hours)**
Analogy between heat and mass, steady and transient mass diffusion, mass convection	

(Total Lecture Hours: 45)

3. <u>Books Recommended:</u>

1	Convective Heat and Mass Transfer, S. Mostafa Ghiaasiaan, CRC Press, 2018
2	Convective Heat Transfer, Sadik Kakaç, Yaman Yener, Anchasa Pramuanjaroenkij, CRC Press, 2014
3	Conduction and Radiation, K. Muralidhar and J. Banerjee, Narosa Publishers, 2010
4	Essentials of Radiation Heat Transfer, C. Balaji, John Wiley& Sons, 2014
5	Thermal Radiation Heat Transfer, R. Siegel, and J.R.Howell, Taylor &Francis,2002

METD104	:	ENERGY CONVERSION SYSTEMS	L	T	P	Credits
			3	1	0	04

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe the mechanism of various types of steam boilers, steam turbine
CO2	Carry out design and analysis of boiler accessories, condenser, feed water heater, cooling tower
CO3	Assess combustion mechanism, combustion equipments, heat balance sheet of boiler plant
CO4	Describe the mechanism of non-conventional power generation and direct energy conversion
CO5	Analyze the Gas turbine power plant to improve overall performance
CO6	Evaluate power plant economy and evaluate steam power plant to improve performance

2. Syllabus:

Steam Power Plant	**(12 Hours)**
Rankine cycle, mean temperature of heat addition, reheat cycle, regenerative cycle, reheat-regenerative cycle, feed water heaters, Supercritical pressure cycle, Boiler specifications, Radiant type natural circulation boiler, High pressure forced circulation boilers, heat absorption in boilers, Circulations in down comers and riser, steam drum and its internals, supercritical boiler, Fluidized bed combustion boilers – Bubbling and circulatory, Economizers, Air preheaters, Superheaters, Desuperheaters, Reheaters, fabric filters and bag house collector, electrostatic precipitators, feed water heaters, deaerator, ash handling system, cogeneration power plant, back pressure turbine, pass out turbine Classification of steam turbine, compounding of steam Turbines, Arrangements of steam turbines, Direct contact and Surface condensers, cooling towers, Performance parameters.	
Combustion Equipments and Firing Methods	**(06 Hours)**
Fuel bed combustion, Mechanical Stokers, Pulverized Coal Firing System, pulverisers, coal crushers, burners, Cyclone Furnace, Fluidized Bed Combustion, different regimes, advantages and disadvantages of Fluidized bed combustion, proximate analysis, ultimate analysis, combustion reactions and heat balance sheet, natural draught and mechanical draught	
Renewable Power Generation and Direct Energy Conversion	**(12 Hours)**
Solar power plant: Solar energy- General terms and introduction, solar energy collectors, Solar pond, Low temperature, medium and high temperature power generation, Wind power plant: Introduction, Wind turbine operation, velocity and power from wind, types of wind mills Waste to energy plant	

Direct energy conversion system: Fuel cells : working principle and types of fuel cell, Photovoltaic power system	
Gas Turbine Power Plant	**(07 Hours)**
General aspects of gas turbine, Analysis of gas turbine, performance of gas turbine plant, components, fuels and materials, combined - Gas and steam turbines	
Power Plant Economics	**(08 Hours)**
Introduction, Load-Duration curves, Load factor, Capacity factor, Reserve factor, demand factor, Diversity factor, plant use factor, base load plant, peak load plant, power plant economics – electricity cost, fixed costs and depreciation, Present-Worth Concept, Incremental Heat Rate, Effect of Load Factor on Cost per kWh	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Power plant engineering, P.K Nag, McGraw Hill Education, New Delhi, 2014
2	Power plant Technology by ‘M.M.Ei-Wakil’, McGraw Hill Education, New Delhi, 2010
3	Power plant engineering by R.K. Hegde, Pearson India Education, New Delhi, 2015
4	Power plant engineering by ‘Arrora&Domkundwar’, DhanpatRai& Sons, New Delhi, 2008
5	Power plant engineering by ‘P C Sharma’, S.K. Kataria& Sons, New Delhi, 2010

METD132	:	DESIGN OF HEAT EXCHANGERS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Identify different types of heat exchangers and understand the primary design methodologies
CO2	Design and analyse the double pipe and shell and tube heat exchanger
CO3	Design and perform the thermal performance of tube finned and plate finned heat exchanger
CO4	Estimate thermal performance of Gasketed and Spiral plate heat exchanger
CO5	Estimate the pressure drop in the tubular and extended surface heat exchanger
CO6	Estimate furnace outlet temperature using furnace model

2. Syllabus:

Introduction	**(05 Hours)**
Introduction, application of heat exchanger, classification of heat exchanger, design and simulation of heat exchanger, Review of heat transfer principles & convection correlation, Basic design methodologies, Net Transferable Units method and Logarithmic Mean Temperature, Examples.	
Design of Tubular Heat Exchanger	**(10 Hours)**
Heat transfer coefficient, double pipe heat exchanger design, Shell & tube type heat exchangers, nomenclature, J-factors, conventional design methods, bell, Delaware method	
Design of Extended Surface Heat Exchanger	**(15 Hours)**
Enhancement of heat transfer compact heat exchanger, Compact heat exchangers, J-factors, Design method Extended surface heat exchanger, Rating problem of tube finned heat exchanger, Rating problem of plate finned heat exchanger, Pressure drop calculations and tutorials, Sizing problem.	
Design Of Plate Heat Exchangers	**(05 Hours)**
Introduction, Types of the plate heat exchanger, thermal design of Gasketed plate heat exchanger, thermal design of spiral plate heat exchanger	
Heat Exchanger Pressure Drop Analysis	**(05 Hours)**
Importance of pressure drop, Major contributions to the heat exchanger pressure drop, Tubular heat exchanger pressure drop, Extended surface heat exchanger pressure drop, Plate heat exchanger pressure drop	
Furnace Design	**(05 Hours)**

Design development of Stirred Reactor Furnace model, Estimate the furnace outlet temperature

(Total Lecture Hours: 45)

3. Books Recommended:

1	Shah, R.K. and Sekulic D.P., "Fundamentals of Heat Exchanger Design", John Wiley & Sons, Inc, 2003
2	Kays, V.A. and London, A.L., "Compact Heat Exchangers," McGraw Hill, 2002
3	Saunders, E.A.D., "Heat Exchangers Selection Design and Construction," Longman Scientific and Technical, N.Y., 2001
4	Holger Martin, "Heat Exchangers" Hemisphere Publ. Corp., Washington, 2001
5	Kuppan, T., "Heat Exchanger Design Handbook", Macel Dekker, Inc., N.Y. , 2000
6	Seikan Ishigaki, "Steam Power Engineering, Thermal, and Hydraulic Design Principles," Cambridge Univ. Press, 2001

METD134	:	THEORY AND DESIGN OF CRYOGENIC SYSTEMS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Select suitable cryogen and material for developing cryogenic systems for different applications.
CO2	Carry out design and analysis of gas liquefaction systems and cryogenic refrigeration systems, including cryocoolers.
CO3	Select proper cryogenic insulating material and designing of cryogenic insulation.
CO4	Analyse gas purification and separation system using cryogenics.
CO5	Select and design storage, handling, and transfer systems for cryogens.
CO6	Design vacuum system for the cryogenic application.

2. Syllabus:

INTRODUCTION AND APPLICATIONS	**(02 Hours)**
CRYOGENICS FLUIDS	**(02 Hours)**
Properties of Air, Oxygen, Nitrogen, Hydrogen, Helium and its isotopes	
PROPERTIES AND SELECTION OF MATERIALS	**(03 Hours)**
Study of material properties & their selection for the cryogenic application.	
GAS LIQUEFACTION and REFRIGERATION SYSTEMS	**(10 Hours)**
Basics of Refrigeration, Ideal system, Linde Hampson system, Precooled Linde Hampson system, Linde dual pressure system, Claude system, Heylandt system, Kapitza system, Collins cycle	
CRYOGENIC INSULATION	**(07 Hours)**
Vacuum insulation, Multilayer insulation (MLI), Methods of measuring the effective thermal conductivity of MLI, Liquid & vapor shield, Evacuated porous insulation, Gas-filled powders, and fibrous materials, Solid foams, Vacuum technology	
CRYOCOOLERS	**(06 Hours)**
Ideal Stirling cycle, Design parameters (Schmidt's Analysis), GM cryocooler, Pulse Tube cryocooler, Phasor Analysis	
CRYOGENIC INSTRUMENTATION	**(05 Hours)**
Peculiarities of cryogenic strain measurement, Pressure, Flow, Density, Temperature, and liquid level measurement for cryogenic application	
STORAGE & HANDLING SYSTEMS	**(03 Hours)**
Dewar vessel design, Piping, Support systems, Vessel safety devices and storage systems, Industrial storage systems	

TRANSFER SYSTEMS	(03 Hours)
Transfer from storage, Uninsulated transfer lines, Insulated lines, and Transfer system components.	
GAS SEPARATION	**(04 Hours)**
Principles of gas separation, Ideal system	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Haselden, C., Cryogenic Fundamentals, Academic Press, 2001
2	Barron R., Cryogenic Systems, Plenum Press, 2001
3	Walker G., Cryocoolers, Springer, 2014
4	Mikulin, Y., Theory and Design of Cryogenic systems, MIR Publication, 2002
5	Barron, R. F., Cryogenics Systems, Oxford Press., USA, 2002

METM136	:	COMBUSTION FOR PROPULSION SYSTEMS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Analyse the combustion system using principles of thermodynamics.
CO2	Model combustion kinetics and chemical explosion mechanisms
CO3	Explain basic concepts about various types of flames; modelling and application to energy systems.
CO4	Analyse combustion characteristics and how these can be measured.
CO5	Illustrate different type of pollutants generated by combustion, their effects on health and on the environment and various methods to control it.
CO6	Describe different combustion mechanisms and how these can be efficiently used in engineering applications.

2. Syllabus:

Introduction	**(04 Hours)**
Introduction to combustion, Applications of combustion, Types of fuel and oxidizers, Characterization of fuel, Various combustion mode, Scope of combustion, Fundamental laws of transport phenomena, Conservations Equations	
Thermodynamics of Combustion	**(08 Hours)**
Mixture composition, energy and entropy properties of gaseous mixtures, Thermodynamic properties of reacting mixtures, Laws of thermodynamics, Stoichiometry, Thermochemistry, adiabatic temperature, chemical equilibrium. Conditions of chemical equilibrium, equilibrium constant, challenges in chemical equilibrium	
Combustion Kinetics	**(08 Hours)**
Basic Reaction Kinetics, Elementary reactions, Chain reactions, Multistep reactions, simplification of reaction mechanism, Global kinetics reaction rate formula, approximations for construction of global reaction rate, global rates of hydrocarbon fuels	
Chemical Mechanisms	**(03 Hours)**
Explosive and oxidative characteristics of fuels, Criteria for explosion, Explosion limits and oxidation of hydrogen, Carbon monoxide and hydrocarbons	
Premixed Flames	**(06 Hours)**
Laminar premixed flame, laminar flame structure, Stability limits of laminar flames, Laminar flame speed, Flame speed measurements, Flame stabilizations, Ignition and quenching, Turbulent flames, turbulent flame speed, external aided ignition (spherical propagation, plane propagation), auto ignition, flammability limits	
Diffusion Flames	**(06 Hours)**
Laminar Diffusion flames, turbulent diffusion flames, Schvab-Zel'dovich formulation, Burke-Schumann problem, Gaseous Jet diffusion flame, Droplet Combustion, Liquid fuel combustion, Atomization, Spray and Solid fuel combustion	
Combustion and Environment	**(04 Hours)**
Atmosphere, Chemical Emission from combustion, Quantification of emission, mechanisms of	

pollutant formation during combustion, pollutants reduction in conventional combustors, pollutants reduction by control of flame temperature, dry low-oxides of nitrogen combustors, lean premix per vaporize combustion, rich-burn quick-quench lean burn combustor, catalytic combustion, correlations and modelling of oxides of nitrogen and carbon monoxide emission	
Combustion Process in Propulsion Systems	**(06 Hours)**
Principal ideas of combustion in gas turbine, solid propellant rockets: Erosive burning, and liquid propellant rockets	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Kuo K.K., "Principles of Combustion", John Wiley, USA, 2005
2	Turns S.R., "An Introduction to Combustion", New York: McGraw-Hill, NY, USA, 2017
3	Law C.K., "Combustion Physics", Cambridge University Press, Cambridge, United Kingdom, 2010
4	Mishra D.P., "Fundamentals of Combustion", Prentice Hall of India, New Delhi, INDIA, 2010
5	Mukunda H. S., "Understanding Combustion", Universities Press, Hyderabad, Telangan, 2009

METD138	:	BIOFLUID AND BIOHEAT TRANSFER	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course, the students will be able to

CO1	Describe cardiovascular systems and significant fluid flow problems in large arteries
CO2	Apply the knowledge of fluid mechanics to analyze the flow behavior in biological systems
CO3	Apply bio-heat transfer models to analyze human body thermoregulation
CO4	Explain the basics of tissue optics and model light transport in the tissue layer
CO5	Apply knowledge of porous media in bioheat transfer applications
CO6	Develop model to study light transport in biological tissue.

2. Syllabus:

BIOFLUIDICS	**(10 Hours)**
Fluid mechanics review, Solid Mechanics Review, Rheology of blood, Blood morphology, Blood flow in a channel, Viscometers, and Rheometers, Viscoelasticity, Introduction to Biomicrofluidics, pressure-driven flows, surface tension driven flows, modulating surface tension, Flow Bifurcation, Pulsating flow	
HUMAN BODY THERMOREGULATION	**(12 Hours)**
Introduction to human body thermoregulation; Metabolism; Convection over the body surface, sweating, respiration; Heat transfer to blood vessels; Body heat balance; Hypothalamus; Maintaining body temperatures; Cold thermoreceptors and heat receptors; Body temperature measurement (mean skin temperature, mean torso temperature, and core temperature); Temperature-induced dynamic change of blood flow (Vasodilation and Vasoconstriction); Body heat storage; thermal comfort; Cold-spell and heat wave conditions, fever, Thermo-regulation models, Bio-heat transfer models, Blood perfusion as a heat-removal/addition mechanism	
TISSUE OPTICS	**(12 Hours)**
Fundamental interactions of light with tissue, Overview of tissue optics, Monte Carlo modeling of light transport in Tissue (Steady State and Time of Flight), Measurement of Ex vivo and In Vivo Tissue optical properties, Thermal Damage and Rate Processes in Biological Tissues, Hypothermia, and hyperthermia	
SPECIAL TOPICS	**(11 Hours)**
Application of bioheat transfer - Detection of breast cancer, Tumor thermal treatment, Cryobiology, Determination of degree of skin burn, Porous and Bioporous Media, Darcy equation for momentum conservation, Convective heat and mass transfer in porous media, Application to targeted drug delivery, Topics of current interest	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Transport phenomena in biological systems by G.A. Truskey, F. Yuan, and D.F. Katz, Pearson
2	Applied biofluid mechanics by L. Waite and J. Fine, McGraw-Hill Education
3	Optical-thermal response of laser-irradiated tissue (Vol. 2) by A.J. Welch, J. Martin, and C.V. Gemert, Springer, New York
4	Heat conduction, 3rd Edition by L.M. Jiji, Springer Science & Business Media
5	Nano and bio heat transfer and fluid flow by M. Ghassemi, and A. Shahidian, Academic Press
6	Porous media: Applications in biological systems and biotechnology by K, Vafai, Springer, Cham.

METD140	**:**	**NANOFLUIDS AND ITS APPLIATIONS IN THERMAL SYSTEMS**	**L**	**T**	**P**	**Credits**
			3	**0**	**0**	**03**

1. Course Outcomes (Cos):

At the end of the course, the students will be able to:

CO1	Select the suitable approach for the synthesis of nanofluid
CO2	Explain the factors affecting the stability and measure the stability of nanofluid
CO3	Measure or predict the thermal properties of nanofluids
CO4	Determine the enhancement in convection heat transfer in nanofluid
CO5	Apply the nanofluid in the various thermal systems at the lab and industrial scale
CO6	Identify the Challenges and Limitations of Nanofluids to Engineering Applications

2. Syllabus:

Introduction and Synthesis of Nanofluids	**(07 Hours)**
Introduction to heat transfer, micron-sized solid particles, fundamentals and advantages of nanofluids, classification, synthesis of nanofluids, General issues of concern, micro emulsion-based methods for nanofluids, Solvothermal synthesis, synthesis using supports, magnetic nanofluids, Inert gas condensation	
Stability of Nanofluids	**(08 Hours)**
Key Concepts of stability, factors affecting stability, Electrokinetic phenomena and electrical double layer, Zeta Potential. Interaction of particles: aggregation, flocculation, and coagulation. Sedimentation velocity, Brownian motion, DLVO theory, synthesis approach of nanofluids, stability measurement, and methods to improve stability	
Thermal Properties of Nanofluids	**(08 Hours)**
Density, specific heat capacity, thermal conductivity: measurement techniques, the effect of particle material, base liquid, temperature, concentration, size, and shape of nanoparticles. Mechanisms of thermal conductivity enhancement, classical models for suspensions of particles in a liquid, Brownian motion of nanoparticles, nanolayer, clustering of nanoparticles, combined effects of Ballistic Phonon Transport and clustering, combined effects of Brownian motion and clustering. Viscosity: classical and theoretical models for suspensions of particles in a liquid, effects of nanofluid parameters, the combined effect of enhanced thermal conductivity and increased viscosity on heat transfer	
Heat Transfer Enhancement in Nanofluids	**(08 Hours)**
Forced convective heat transfer in nanofluids: horizontal and vertical loops. Free convective heat transfer in nanofluids, nanofluid feasibility criteria for laminar and turbulent flow conditions. Flow stability in thermosyphon loops, surface modified channels, nanofluid flow	

and heat transfer enhancement using an electric and magnetic field, pool boiling of nanofluids, critical heat flux in pool boiling of nanofluids	
Applications of Nanofluids in Thermal Systems	**(08 Hours)**
Heat Pipes: nanofluids for heat transfer intensification in mini loop thermosyphons with a transparent envelope. Nanocoating in Heat Pipes. Nanofluids for solar energy retrieval: solar thermal collectors, optical properties of nanofluids, extinction coefficient, solar stills. Nano-encapsulated phase change material. Electronic chip cooling. Nano refrigerants and nano lubricants in air conditioning systems. Thermal battery management systems in electric vehicles	
Challenges and Limitations of Nanofluids to Engineering Applications	**(06 Hours)**
Nanofluid stability, high cost of nanofluids, degradation of fluid transfer components. Health, safety, and environmental issues related to the manufacturing and usage of nanofluids and Nanoparticles. Performance comparison criteria for nanofluids. Hybrid Nanofluids	

(Total Lecture Hours: 45)

3. <u>Books Recommended:</u>

1	S.K. Das, S.U.S. Choi, W. Yu, T. Pradeep, Nanofluids – Science and Technology, John Wiley & Sons, 2008
2	M. Rebay, S. Kakaç, R.M. Cotta, Microscale and NanoscaleHeat Transfer –Analysis, Design and Application, CRC Press, 2016
3	V. Bianco, O.Manca, S.Nardini, K.Vafai, Heat Transfer Enhancement with Nanofluids, CRC Press, 2015
4	M.Hatami, D.Jing, Nanofluids – Mathematical, Numerical, and Experimental Analysis, Academic Press, 2020

METD142	:	MACHINE LEARNING FOR THERMAL SYSTEMS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Understand different types of machine learning and map problems to different classes of machine learning algorithms
CO2	Describe and apply machine-learning algorithms including decision trees, naïve Bayes, and logistic regression.
CO3	Design and implement advanced neural network architectures, including Multilayer Perceptrons (MLPs), Convolutional Neural Networks (CNNs), and Recurrent Neural Networks (RNNs) (including LSTM and GRU variants), to solve complex real-world problems.
CO4	Utilize Bayesian Regression, Binary Trees, Random Forests, Support Vector Machines (SVM), Naïve Bayes, k-Means, k-Nearest Neighbors (kNN), Gaussian Mixture Models (GMM), and Expectation Maximization (EM) to analyze and optimize mechanical systems
CO5	Evaluate the performance of algorithms and compare different machine learning techniques.
CO6	Apply structured probabilistic models, Monte Carlo methods, autoencoders, and generative adversarial networks (GANs) to analyze and optimize mechanical systems

2. Syllabus:

MATHEMATICAL BASICS	**(04 Hours)**
Introduction to Machine Learning, Linear Algebra, Probability	
COMPUTATIONAL BASICS	**(04 Hours)**
Numerical computation and optimization, Introduction to Machine Learning packages	
LINEAR AND LOGISTIC REGRESSION	**(05 Hours)**
Bias/Variance Tradeoff, Regularization, Variants of Gradient Descent, MLE, MAP, Applications	
NEURAL NETWORKS	**(14 Hours)**
Multilayer Perceptron, Backpropagation, Applications, **Convolutional Neural Networks:** CNN Operations, CNN architectures, Training, Transfer Learning, Applications, **Recurrent Neural Networks:** RNN, LSTM, GRU, Applications	
CLASSICAL TECHNIQUES	**(09 Hours)**
Bayesian Regression, Binary Trees, Random Forests, SVM, Naïve Bayes, Applications, k-Means, kNN, GMM, Expectation Maximization, Applications	
ADVANCED TECHNIQUES	**(09 Hours)**

Structured Probabilistic Models, Monte Carlo Methods, Autoencoders, Generative Adversarial Networks
Total Lectures 45 Hours

(Total Lecture Hours: 45)

3. Books Recommended:

1	Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning (Adaptive Computation and Machine Learning series), The MIT Press, 2016
2	Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2016
3	Geoff Dougherty, Pattern Recognition and Classification: An Introduction, Springer, 2013
4	Sebastian Raschka, Yuxi (Hayden) Liu, Vahid Mirjalili, Dmytro Dzhulgakov, Machine Learning with PyTorch and Scikit-Learn: Develop machine learning and deep learning models with Python. Packt Publishing Ltd., 2022
5	Manaranjan Pradhan, U Dinesh Kumar, Machine Learning using Python, Wiley, 2020
6	Andreas C. Müller, Sarah Guido, Introduction to Machine Learning with Python: A Guide for Data Scientists, 2016

METD144	:	FLOW AND FLAME DIAGNOSTICS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (Cos)

At the end of the course, the students will be able to:

CO1	Explain the need for diagnostics experiments in fluid flow and reacting flow
CO2	Explain the concepts and methods of various diagnostics techniques in fluid flow and reacting flow
CO3	Explore different analysis techniques commonly used in diagnostics experimental work
CO4	Explore modern diagnostic techniques in fluid flow and reacting flows
CO5	Interpret diagnostics data in fluid mechanics and combustion
CO6	Apply the knowledge of flow and flame diagnostics to real life systems.

2. Syllabus:

INTRODUCTION TO OPTICAL FLOW DIAGNOSTICS	**(08 Hours)**
Importance of diagnostics, Intrusive Vs. Non-Intrusive Measurements, Point Vs. Planar Measurements, Spatial Vs. Temporal Resolution, Time Vs. Ensemble Averaging,	
EQUIPMENT'S FOR DIAGNOSTICS	**(10 Hours)**
Lasers, Camera, Synchronization, Seeding, Light-sheet optics, Image Processing	
TECHNIQUES	**(14 Hours)**
Velocity — 2D-2C PIV, 2D-3C PIV (Stereo), 3D-3C PIV (Tomographic), LDVHeat Release Rate —Chemiluminescence Imaging (CH, OH, C2, CO2), PLIF (CH, OH, HCHO, H), Temperature —2Line PLIF, IR Camera, Thermographic Phosphors, Mixture Fraction, Acetone PLIF, Rayleigh Scattering.	
MISCELLANEOUS	**(13 Hours)**
Soot— LII, Droplet & Spray Measurements — ILIDS-(Droplet Sizing), PDPA (Velocity & Size), Density Gradient—Schlieren, Rhodhamine PLIF, Shadowgraphy.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	H. C. van de Hulst, Light Scattering by Small Particles, Dover, New York, USA,1981
2	T. D. McCay and J. A. Roux, eds., Combustion Diagnostics by Nonintrusive Methods, Progress in Astronautics and Aeronautics Series, Vol. 92, AIAA, Washington, DC, USA, 1984
3	A. C. Eckbreth, Laser Diagnostics for Combustion Temperature and Species, 2nd edition, Gordon & Breach, 1996
4	M. Raffel, C. E. Willert, J. Kompenhaus, Particle Image Velocimetry: A Practical Guide, Springer-Verlag, 1998
5	K. Kohse-Hoinghaus and J. B. Jeffries, eds., Applied Combustion Diagnostics, Taylor and Francis, 2002
6	R. J. Goldstein, Fluid Mechanics Measurements, Taylor and Francis, 1996
7	LacknerMaximillan, Avinash Kumar Agarwal, Franz Winter, “Handbook of Combustion, Vol. 2”, Wiley Publication, 2010

METD146	:	TRANSPORT IN POROUS MEDIA	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (Cos):

At the end of the course, the students will be able to:

CO1	classify the basics of porous media properties
CO2	convert the microscopic pore-scale equations into the macroscopic domain-scale equations
CO3	describe various experimental techniques available to measure different properties of porous media
CO4	perform a numerical simulation to close the volume-averaged equation
CO5	Explain the basics of local thermal equilibrium and local non-thermal equilibrium approach
CO6	derive volume-averaged equations for multiphase flow

2. Syllabus:

Basics of porous media flow, Basic quantities including porosity, filtration velocities, single and two-phase flows, measurement of essential parameters including porosity, permeability, relative permeability, capillary pressure	**(06 Hours)**
Principal components of a permeability tensor, measurements of this tensor using 1-D and radial flow methods	**(04 Hours)**
Basics of tensor manipulations and tensor algebra, Definition of various averages, averaging theorems and their derivations	**(05 Hours)**
Volume averaging applied to single-phase flows, Derivation of Darcy's law using the averaging problems, Development of closure formulation, an overview of the Hazen-Dupuit-Darcy (HDD) model, extensions of HDD model	**(08 Hours)**
Volume averaging applied to two-phase flows: Derivation of the two permeability tensors along with the two viscous-drag tensors, Development of appropriate closure formulation, Development of a workable closure formulation using transformations	**(09 Hours)**
Experimental techniques: Flow visualization, quantitative methods, inverse parameter estimation	**(05 Hours)**
Special Topics: Hat conduction in a porous medium, Forced convection through a porous medium, Radiation heat transfer in a porous medium, numerical techniques	**(08 Hours)**

(Total Lecture Hours: 45)

3. Books Recommended:

1	Principles of Heat Transfer in Porous Media, by M. Kaviany, Springer New York, 1995
2	Transport Phenomena in Porous Media, Volumes I-III, edited by D. R. Ingham and I. Pop, Elsevier, New York,2005

3	Dynamics of Fluids in Porous Media, J. Bear, Dover, 1988
4	Introduction to Modeling of Transport Phenomena in Porous Media, J. Bear and Y. Bachman, Kluwer Academic Publishers, London, 1990
5	Enhanced Oil Recovery, L.W. Lake, Gulf Publishing Co. Texas, 1989
6	The Mathematics of Reservoir Simulation, R.E. Ewing, SIAM Philadelphia, 1983
7	Stochastic Methods for Flow in Porous Media: Coping with Uncertainties, Zhang, D., Academic Press, California, 2002
8	The Method of Volume Averaging, S. Whitaker, Springer, New York, 1999

METD148	:	RENEWABLE ENERGY SYSTEMS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (Cos):

At the end of the course, the students will be able to:

CO1	Design solar systems for a given energy utility by applying principles of solar energy Conversion
CO2	Estimate the wind potential and perform power forecast analysis
CO3	Design bio-energy-based systems for a given utility by applying principles of bio-mass to-energy conversion.
CO4	Characterize different types of waste and compare various conversion technologies suitable for industrial applications in line with Government approved RDF and MSW policies
CO5	Compare Hydrogen production methods and use of hydrogen resources with other energy resources in the present context
CO6	Apply the knowledge to real life renewable energy-based systems.

2. Syllabus:

SOLAR RADIATION	(12 Hours)
Extra-terrestrial and terrestrial, Solar radiation measuring instruments, Estimation of Solar Radiation, Various earth-sun angles. Solar Energy Conversion Systems: Solar Thermal Systems: Basics, Flat plate collectors-liquid, and air type. Theory of flat plate collectors, selective coating, advanced collectors, Concentrators: optical design of concentrators, solar water heater, solar dryers, solar stills, Solar ponds, solar cooling and refrigeration, Solar thermal power generation. Solar Photovoltaic Systems: Principle of photovoltaic conversion of solar energy, Solar cells, home lighting systems, Solar lanterns, Solar PV pumps, Govt. policies. Introduction to Solar Photovoltaic Thermal Systems (PV/T): Air-based, Water-based, Refrigerant-based Systems. Solar energy storage options: Electrical and Thermal Energy storage options for Solar Energy	
BIOMASS & BIOENERGY	**(13 Hours)**
Biogas System: Anaerobic digestion, biogas production, Types of digesters, installation, operation and maintenance of biogas plants, Biogas plant manure utilization, and manure values, factors affecting biogas production, Biogas utilization and storage, Compressed Biogas (CBG) production from agro-waste; biogas for motive power generation, design calculations for biogas plants, Govt. policies. Liquid Biofuels: Biodiesel – The mechanism of transesterification, biodiesel fuel characteristics, technical aspects of biodiesel/Ethanol and other liquid fuels utilization in the engine. Biomass gasification: Different types of the gasifier, power generation and applications	
WIND ENERGY CONVERSION SYSTEMS	**(09 Hours)**

History of wind energy, Current status, and future prospects, Wind energy in India. Power available in the wind, Components of Wind Energy Conversion Systems, Horizontal and Vertical axis wind turbine, Wind turbine power and torque characteristics, Tip speed ratio, Wind speed prediction and forecasting, Betz limit, Govt. Policies	
WASTE TO ENERGY CONVERSION	**(06 Hours)**
Introducing Municipal Solid Waste Management; Waste Generation and characterization, Waste Processing Techniques; Source Reduction, Biological Conversion Products: Compost and Biogas, Incineration pyrolysis and Energy Recovery, waste plastic, RDF/Sewage utilization, Govt. Policies on MSW and RDF, Introduction to Microbial Fuel Cell	
HYDROGEN ENERGY AND FUEL CELLS	**(05 Hours)**
Benefits of Hydrogen Energy, Hydrogen Production Technologies, Hydrogen Energy Storage, Use of Hydrogen Energy, Electrolysis, Bio-hydrogen Production, Biogas reformation to Syngas, Basic principle of working of fuel cell	

(Total Lecture Hours: 45)

3. Books Recommended:

1	J. A. Duffie and W.A. Beckman, Solar Engineering and Thermal Processes, John Wiley and Sons., 2013
2	G. N. Tiwari, Solar Energy, Narosa Publishing House Pvt. Ltd., 2012
3	H. S. Mukunda, Understanding Clean Energy, and fuels from biomass. Wiley India Pvt. Ltd, 2011
4	K. M. Mital, Biogas Systems, Principle and Applications. New Age International Ltd, 1996
5	G. D. Rai, Non-Conventional Energy Sources, Khanna Publication, 1988
6	Prabir Basu, Biomass Gasification and Pyrolysis: Practical Design and Theory
7	Gasification: Christopher Higman: Gulf Professional Publishing, 2nd Edition

METD150	:	DESIGN OF SOLAR THERMAL SYSTEM	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Calculate inclination angle of solar collectors
CO2	Design solar water and air heater
CO3	Design solar concentrator for specific application
CO4	Design solar powered desiccant air conditioning system
CO5	Design solar powered atmospheric water harvesting system
CO6	Design solar thermal desalination system

2. Syllabus:

FUNDAMENTALS OF SOLAR ENERGY	**(04 hours)**
Energy demand and potential of solar energy, Reckoning of time, Solar angles, Solar radiation and resource	
SOLAR COLLECTOR	**(16 hours)**
Flat Plate Collector: Basic elements, Performance analysis, Absorptivity, Heat transfer coefficients and correlations, Collector efficiency and heat removal factors, Effect of various parameters, Case study: application of flat plate collector for air heating and water heating Evacuated tube Collector: Principle of working, advantages of evacuated tube collector over flat plate collector, Types of evacuated tubes, Thermal analysis, Case study: application of flat plate collector for air heating and water heating Parabolic trough collector: Principle of working, optical and thermal analysis of parabolic trough collector, End effect and blocking in a parabolic trough collector, Case study: application of parabolic trough collector for process heat Parabolic dish collector and Scheffler reflector: Principle of working, construction, tracking mechanism, application of parabolic dish collector and Scheffler reflector.	
SOLAR REFRIGERATION AND AIR CONDITIONING	**(10 hours)**
Scope of solar cooling, Photovoltaic refrigeration, Adsorption/ absorption refrigeration using solar heat, solid and liquid desiccant, construction of desiccant bed, desiccant wheel	

and desiccant coated heat exchanger. Heat and mass balance of desiccant wheel, Construction and principle of working of solar powered desiccant air conditioning system, selection of solar collector, Energy, exergy and economic analysis. Concept of heat storage.	
ATMOSPHERIC WATER HARVESTING USING SOLAR HEAT	**(08 hours)**
Need of atmospheric water harvesting system, selection of desiccant material and solar collector, Construction and principle of working of solar powered atmospheric water harvesting system, effect of design and operating parameters on daily yield, Energy, exergy and economic analysis.	
SOLAR THERMAL DESALINATION	**(07 hours)**
Need of desalination system, types of desalination techniques, solar thermal desalination, solar still, improvements in solar still, limitations of solar still, Humidification-dehumidification desalination using solar heat, selection of solar collector, heat and mass balance of humidifier, packing materials of humidifier. effect of design and operating parameters on daily yield, Energy, exergy and economic analysis.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Kalogirou S. A., Solar Energy Engineering: Processes and Systems, Academic Press, 3rd Edition, 2023
2	Garg H.P., Prakash J., Solar Energy: Fundamentals and Applications, Tata McGraw-Hill, 1st Revised Edition, 2016
3	Goswami D. Y., Principles of Solar Engineering, CRC Press, 4th Edition, 2022
4	Duffie J. A., Beckman W.A., Solar Engineering of Thermal Processes, John Wiley and Sons, 4th edition, 2013
5	Sukhatme S., Nayak J: Solar Energy: Principles of Thermal Collection and Storage, Tata McGraw Hill, 3rd edition, 2008

METD172	:	COMPUTATIONAL FLUID DYNAMICS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Develop an understanding of major theories, approaches and methodologies used in CFD
CO2	Build skills in the actual implementation of CFD methods (e.g., boundary conditions, different numerical schemes etc.)
CO3	Acquire a working knowledge of computational complexity, accuracy, stability, and errors in solution procedures
CO4	Develop numerical models for fluid flow and heat transfer problems
CO5	Explain advanced numerical techniques such as LBM and Meshless techniques.
CO6	Gain experience in applying CFD analysis to real-life engineering designs.

2. Syllabus:

INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS AND PRINCIPLE OF CONSERVATION	(05 Hours)
Introduction of Computational Fluid Dynamics: What, When, and Why?, CFD Applications, Numerical vs. Analytical vs. Experimental, Conservation of mass, Newton's second law of motion, Expanded forms of Navier-Stokes equations, Conservation of energy principle, Special forms of the Navier-Stokes equations, Classification of second-order partial differential equations, Initial and boundary conditions, Governing equations in generalized coordinates.	
FUNDAMENTALS OF DISCRETIZATION	**(08 Hours)**
Discretization principles: Pre-processing, Solution, Post-processing, Finite Element Method, Finite difference method, Well posed boundary value problem, Possible types of boundary conditions, Conservativeness, Boundedness, Transportiveness, Higher-order schemes to FDM, Finite volume method (FVM), Illustrative examples: 1-D steady-state heat conduction without and with constant source term	
FINITE VOLUME METHOD	**(06 Hours)**
Some Conceptual Basics and Illustrations through 1-D Steady-State Diffusion Problems: Physical consistency, Overall balance, FV Discretization of a 1-D steady-state diffusion type problem, Composite material with position-dependent thermal conductivity, Four essential rules for FV Discretization of 1-D steady-state diffusion type problem, Source term linearization, Implementation of boundary conditions	
DISCRETIZATION OF UNSTEADY STATE PROBLEMS	**(04 Hours)**
1-D unsteady-state diffusion problems: implicit, fully explicit and Crank-Nicholson scheme, FVM for 2-D unsteady-state diffusion problems	

DISCRETIZATION OF CONVECTION-DIFFUSION EQUATIONS	(06 Hours)
A Finite Volume Approach: Finite volume discretization of convection-diffusion problem: Central difference scheme, Upwind scheme, Exponential scheme and Hybrid scheme, Power-law scheme, Generalized convection-diffusion formulation, Finite volume discretization of two-dimensional convection-diffusion problem, The concept of false diffusion, QUICK scheme	
DISCRETIZATION OF NAVIER STOKES EQUATIONS	**(06 Hours)**
Discretization of the Momentum Equation: Stream Function-Vorticity approach and Primitive variable approach, Staggered grid and Collocated grid, SIMPLE Algorithm, SIMPLER Algorithm	
SPECIAL TOPICS	**(10 Hours)**
Unstructured Grid Formulation, An overview of Finite Element Method, boundary element method, Lattice Boltzmann Method, Meshless Technique	

(Total Lecture Hours: 45)

3. Books Recommended:

1	S.V.Patankar, Numerical Heat Transfer and Fluid Flow, McGraw-Hill
2	T. J. Chung, Computational Fluid Dynamics, Cambridge University Press
3	H.K.Versteeg& W. Malalasekera, An Introduction to Computational Fluid Dynamics, Longman Scientific & Technical
4	J. H. Ferziger and M.Peric, Computational Methods for Fluid Dynamics,Springer
5	John C. Tannehill, Dale A.Anderson and Richard H. Pletcher, Computational Fluid Mechanics and Heat Transfer, Taylor &Francis
6	John D.Anderson Jr, Computational Fluid Dynamics, McGraw Hill Book Company
7	J.Blazek, Computational Fluid Dynamics: Principles and Applications, Elsevier

METD174	:	FUNDAMENTALS OF ELECTRIC VEHICLES	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the basics of electric vehicles, their architecture, technologies, and fundamentals.
CO2	Calculate various forces acting on the moving vehicle, power, and torque required to drive the vehicle, drive cycles and energy consumed.
CO3	Understand battery parameters such as SoC, SoH, factors affecting battery cell lifecycle and parameters to select EV battery
CO4	Design battery pack and BMS based on mechanical, thermal, and electric aspects
CO5	Explain various methods of battery thermal management
CO6	Explain torque production, d-equivalent, chargers and charging standards

2. Syllabus:

INTRODUCTION	(04 Hours)
Overview of electric vehicles in India, Basics of Batteries, Charging and swapping infrastructure, source of Lithium for batteries, EV subsystems	
VEHICLE DYNAMICS	**(05 Hours)**
Forces acting when a vehicle moves, Aerodynamics drag, rolling resistance and uphill resistance, power, and torque to accelerate	
VEHICLE SUBSYSTEMS: EV POWER-TRAIN	**(12 Hours)**
Concept of the drive cycle, Drive cycles and energy used per km, EV subsystem: Design of EV drive train, Introduction to battery parameters, why lithium-Ion battery? Batteries in the future, Li-Ion battery cell, State of charge and state of health estimation and self-discharge, battery pack development, computation of effective cost of the battery, charging batteries, Fundamentals of battery pack design, mechanical design, thermal design, electrical design, BMS design of the electric vehicle	
BATTERY THERMAL MANAGEMENT	**(08 Hours)**
Passive cooling, Active cooling	
VEHICLE ACCESSORIES	**(10 Hours)**
EV motors and controllers, power and efficiency, torque production, speed and back EMF, the-q equivalent circuit, field-oriented control, three-phase AC, thermal design, engineering considerations, future frontiers	
BATTERY CHARGING AND SWAPPING	**(06 Hours)**

EV chargers: slow or fast, Battery swapping, standardization and onboard chargers, public chargers, bulk chargers/swap stations, Analytics

(Total Lecture Hours: 45)

3. Books Recommended:

1	Ehsani, M.,Gao,Y.,Longo, S. and Ebrahimi,K.M ,Modern electric, hybrid electric, and fuel cell vehicles, by., CRC Press, 2018
2	Husain, I.,Electric and hybrid vehicles: design fundamentals, CRCpress,2010
3	Mi,C.and Masrur,M.A.,,Hybrid electric vehicles: principles and applications with practical perspectives, John Wiley & Sons, 2017
4	Erjavec, J.,, Hybrid, electric, and fuel-cell vehicles, CengageLearning,2012
5	Denton T, Electric and Hybrid Vehicles, Routledge,2020

METD176	:	ENERGY CONSERVATION, MANAGEMENT AND AUDIT	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Apply various energy conservation techniques to estimate energy-saving potential
CO2	Compare various appliances/utilities based on their stars and labeling, benchmarking values, and PAT Scheme in industries
CO3	Calculate the usage of energy for a given industrial utility and suggest a suitable way to minimize energy bill
CO4	Relate the significance of energy usage in buildings and understand the ways to reduce the energy bill
CO5	Compute various performance parameters of HVAC systems and suggest suitable ways for improving energy efficiency
CO6	Build suitable energy conservation module for domestic and industrial systems.

2. Syllabus:

GLOBALANDNATIONAL ENERGYSCENARIO	**(08 Hours)**
Energy consumption in various sectors, Energy resources like Coal, Oil, and Natural Gas – their demand and supply management, Indian energy scenario, Indian Coal & LPG scenario, Primary and Secondary Sources of Energy, Commercial and Non-Commercial Sources, India's installed energy capacity, per capita energy consumption. General aspects of Energy conservation and management, Roles of energy auditors, Roles of an energy manager, Energy policy of industry, Energy Conservation Act and its amendments, PAT Scheme	
ENERGYEFFICIENCYINBOILER, STEAM, AND FURNACE SYSTEM UTILITIES	**(10 Hours)**
Energy conservation opportunities in boiler systems, retrofitting of FBC in conventional boilers, Steam line distribution standard practices including sizing and layouts, selection, operation, maintenance of steam traps, and energy-saving opportunities in steam systems. Energy Efficiency in Furnaces: Sankey diagram, Fuel economy measures in furnaces Insulation and Refractories: Types of insulations, Economic thickness of insulation, Typical refractories for industrial applications. Benchmarking in Glass and Steel Industries	
ENERGY EFFICIENCY IN FURNACES AND REFRACTORIES:	**(06 Hours)**
Sankey diagram, Fuel economy measures in furnaces Insulation and Refractories: Types of insulations, Economic thickness of insulation, Typical refractories for industrial applications. Benchmarking in Glass and Steel Industries	
COGENERATION	**(06 Hours)**

Principle of cogeneration, Technical options for cogeneration, Factors influencing cogeneration choice, Important technical parameters for cogeneration, case study on savings with and without cogeneration	
ENERGY CONSERVATION IN FANS, BLOWERS COMPRESSORS, AND PUMP SYSTEMS	**(10 Hours)**
Energy-saving opportunities, performance evaluation and efficient system operation. Air Systems: Efficient operation of the compressed air system, Leakage tests. Pumps and Pumping Systems: Pump curves, factors affecting pump performance, Energy loss in throttling, Effects of impeller diameter change, Flow control strategy, Variable speed drives, and Energy conservation opportunities.	
ENERGY CONSERVATION IN HVAC AND COOLING TOWERS	**(05 Hours)**

(Total Lecture Hours: 45)

3. <u>Books Recommended:</u>

1	General Aspects of Energy Conservation, Management and Audit: Guide Book for Energy Managers and Energy Auditors; Bureau of Energy Efficiency, Ministry of Power
2	Energy Efficiency in Electrical Utilities: Guide Book for Energy Managers and Energy Auditors; Bureau of Energy Efficiency, Ministry of Power
3	Energy Efficiency in Thermal Utilities: Guide Book for Energy Managers and Energy Auditors; Bureau of Energy Efficiency, Ministry of Power
4	S. A. Roosa, Energy Management Handbook, Fairmont Press, 2018
5	A.Thumann, Handbook of Energy Audits, Fairmont Press, 2012
6	Energy Conservation Guide book by Dale R Patrick; Taylor and Francis; 3rd Edition

METD178	:	OPTIMIZATION TECHNIQUES	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

CO1	Formulate mathematical models for practical problems based on the information provided
CO2	Conduct sensitivity and post optimality analysis of a solution to ensure appropriate solutions that will be deployed in real-world situations
CO3	Apply evolutionary algorithms to solve single objective problems where analytical methods are not suitable.
CO4	Apply evolutionary algorithms to solve complex engineering problems for multiple objectives where analytical methods are not suitable.
CO5	Apply appropriate optimization techniques to solve single and multiobjective engineering problems
CO6	Develop codes of optimization models using MATLAB software for various engineering problems.

2. Syllabus:

Introduction to Optimization, Linear Programming – Formulation, Graphical method, simplex method, and special cases	**(04 Hours)**
Sensitivity Analysis and post optimality analysis – changes in resources and objective function, changes affect feasibility and optimality, duality, dual simplex algorithm, generalize simplex algorithm	**(08 Hours)**
Traveling salesman problem, Integer programming and dynamic programming	**(06 Hours)**
Introduction to MATLAB, creating and manipulating vectors and matrix, user-defined function, special built-in function to create special vectors and matrices, symbolic math, built-in function to solve linear programming problems	**(06 Hours)**
Nonlinear Programming problems: Graphical method, convex function, convex region, necessary and sufficient conditions, Lagrangian method, Karush-Kuhn-Tucker (KKT) conditions, solving nonlinear problems using MATLAB.	**(07 Hours)**
Introduction to the evolutionary algorithm, introduction to multi-objective optimization, genetic algorithms, differential evolution algorithm, Particle swarm optimization, tabu search, simulated Annealing technique, solving real-life engineering problems using MATLAB	**(14 Hours)**

(Total Lecture Hours: 45)

3. Books Recommended:

1	Sharma, J.K. Operations research: theory and applications. Trinity Press, an imprint of Laxmi Publications Pvt. Limited
2	Hillier, F.S. and Lieberman, G.J. Introduction to operations research: Concepts and *Cases*, Tata McGraw-Hill Education
3	Taha, H.A. Operations research: an introduction. Pearson Education India
4	Rao, S.S. Engineering optimization: theory and practice. John Wiley & Sons
5	Deb, K., 2012. Optimization for engineering design: Algorithms and examples. PHI Learning Pvt. Ltd
6	Vasuki, A. Nature-Inspired Optimization Algorithms. CRC Press
7	Goldberg, D.E. Genetic algorithms: in search, optimization and machine learning. Pearson Education India

METD180	:	TURBULENCE AND TURBULENT FLOWS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs)

At the end of the course, the students will be able to

CO1	Evaluate turbulent flows.
CO2	Use self-preservation solutions for free shear flows (jets, wakes, etc.)
CO3	Choose a turbulence model for computational flow analysis (CFD)
CO4	Evaluate and interpret experimental measurements
CO5	represent turbulent flows statistically
CO6	Apply the knowledge of turbulence and turbulent flows to real life problems.

2. Syllabus:

INTRODUCTION	**(02 Hours)**
Nature of turbulence, Method of analysis, generation and diffusion of turbulence, Length scales in turbulent flows.	
TURBULENT TRANSPORT OF MOMENTUM AND HEAT	**(10 Hours)**
The Reynolds equations, elements of the kinetic theory of gases, Estimates of Reynolds stress, Turbulent heat transfer, and Turbulent shear flow near the rigid wall.Transport in stationary, homogeneous turbulence, Transport in shear flows, Dispersion of contaminants, Turbulent transport in evolving flows**.** Dynamics of Turbulence—Kinetic energy of mean flow, Kinetic energy of the turbulence, Vorticity dynamics, The dynamics of temperature fluctuations	
SHEAR FLOWS	**(12 Hours)**
Boundary Free Shear Flows—Almost parallel two-dimensional flows, turbulent wakes, The wake of a self-propelled body, turbulent jets and mixing layers, the comparative structure of wakes, jets and mixing layers, and Thermal plumes. Wall Bounded Shear Flows—The problem of multiple scales, turbulent flows in pipes and channels, Planetary boundary layers, The effects of a pressure gradient on the flow in surface layers, The downstream development of turbulent boundary layers	
THE STATISTICAL DESCRIPTION OF TURBULENCE	**(06 Hours)**

The probability density, Fourier transforms and characteristic functions, joint statistics and statistical independence, Correlation functions, spectra, and the central limit theorem.	
SPECTRAL DYNAMICS	**(07 Hours)**
Velocity and Length scales in laminar and turbulent boundary layers, molecular versus turbulent dissipation, Kolmogorov Microscales of Dissipation, One and three-dimensional spectra, The energy cascade, The spectrum of turbulence, The effects of production and dissipation, Time spectra, Spectra of passive scalar contaminants.	
TURBULENCE SIMULATIONS AND MODELLING	**(08 Hours)**
Zero-order models (Algebraic Models), One-Equation Models, Two-Equation Models, Large Eddy Simulation, Direct Numerical Simulation, appropriate turbulence modelling for turbomachinery flows using a two-equation turbulence model.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Tennekes,H. and Lumley, J.L." A first course on turbulence"MIT Press, CambridgeMass., 1972
2	Pope S.B. "Turbulence" Cambridge University Press, Cambridge, U.K., 2000
3	Davidson P.A, "Turbulence" Oxford University Press, Oxford, U.K, 2004
4	Biswas, G. and Eswaran, V. "Turbulent flows" Narosa Publishing House New Delhi, India, 2002
5	Wilcox, D.C. "Turbulence modeling for CFD," DCW Industries, La Canada, CA, 3rdedition 2006
6	Hanjalic, K. and Launder, B. "Modelling of turbulence in engineering and environment – Second-moment route to closure" Cambridge University Press, Cambridge, U.K., 2013
7	Durbin, P .A., and Paterson. Reif, B.A. "Statistical theory and modeling for turbulent Flows"2nd edition, John Wiley, Chichester, U.K, 2011
8	David S-K Ting, "Basics of Engineering Turbulence", Academic Press (Elsevier), 2016
9	Hans-Josef Rath, CarstenHolze, Hans-Joachim Heinemann, Rolf Henke HeinzeHonlinger, "New Results in Numerical and Experimental Fluid Mechanics V", Springer Publications, 2006

METD108	:	COMPUTATIONAL AND EXPERIMENTAL LABORATORY-II	L	T	P	Credits
			0	0	6	03

1. Course Outcomes (COs):

CO1	Develop computer code to solve steady-state, transient heat conduction problems using FVM
CO2	Derive numerical solutions to various convection-diffusion problems using multiple schemes such as central difference scheme, upwind scheme, and hybrid differencing scheme
CO3	Solve lid-driven cavity problem
CO4	Understand and demonstrate the operation of identified system/ instrument/ equipment
CO5	Demonstrate practical skills to work on identified problem
CO6	Develop skills for team effort and coordination through practical group performance

COMPUTATIONAL LAB

COMMERICAL SOLVER

1. Introduction to mesh generation software
2. Introduction to commercial solver
3. Heat transfer simulation through a solid medium (Steady-state/Transient + various boundary conditions + with and without source term)
4. Fluid flow simulation through the channel (Laminar/ Turbulent)
5. Non-isothermal flow simulation through channel/enclosure/over bodies (Laminar + Turbulent)
6. Flow and heat transfer simulation through a porous medium
7. Multiphase modelling & simulation
8. Flow & Heat transfer simulation for various engineering applications

CODING

11. Introduction to compiler, scripts, loops, logical statements
12. FVM code for heat conduction with and without source term
13. FVM code for the pin-fin problem
14. FVM code for convection-diffusion problem based on central difference scheme
15. FVM code for convection-diffusion problem based on the upwind scheme
16. FVM code to analyse false-diffusion of upwind scheme
17. FVM code for convection-diffusion problem based on the hybrid differencing scheme
18. FVM code for the explicit method based transient heat conduction problem
19. FVM code for the implicit scheme based transient heat conduction problem
20. LBM code for channel flow

EXPERIMENTAL Lab

(Any 10 experiments)

1. Calibration of thermocouple
2. Thermal conductivity of insulating powder
3. Heat transfer through composite wall

4. Heat transfer from pin fin apparatus
5. Emissivity measurement
6. Radiation exp-2 (Thermal imaging camera)
7. Performance test on vapor compression refrigeration system
8. Performance test on vapor absorption system.
9. Performance test on Ice plant
10. Performance test on air conditioning plant
11. Performance test on Cascade Refrigeration system
12. Performance test of 4-stroke Petrol Engine.
13. Performance test of 4-stroke Diesel Engine.
14. Heat Balance Preparation for 4-stroke Diesel Engine.
15. Heat Balance Preparation for four-stroke Petrol Engine
16. Determination of friction power of multi-cylinder petrol engine using Morse Test Method.
17. Determination of friction power of single/multi-cylinder petrol engine using Willan’s Line Method.
18. Demonstration of wind tunnel
19. Demonstration of thermal turbomachines
20. Performance on a nozzle test rig
21. Junker’s gas calorimeter
22. Bomb’s calorimeter
23. Redwood viscometer
24. Gas chromatography
25. Heat pipe experiments
26. Pulsating heat pipe experiments
27. Thermosyphon experiments
28. Microchannel heat sink experiment
29. PCM based experiment-1
30. PCM with extended surface experiment-2
31. Combustion flame and analysis experiments
32. Vortex tube refrigeration
33. Liquid nitrogen plant demonstration
34. Pulse tube refrigeration system
35. Two-phase flow experiments
36. Fluid dynamics experiment-1
37. Fluid dynamics experiment-2
38. Automobile demonstration and experiment
39. Free convection experiment
40. Forced convection experiment
41. Heat exchanger experiment-1
42. Heat exchanger experiment-2
43. Measurement experiment-1
44. Measurement experiment-2
45. Calibration of various instruments

DEPARTMENT OF
MECHANICAL ENGINEERING

M.TECH. (TURBOMACHINES)

SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY
Ichchhanath, Surat-395007, Gujarat, India
www.svnit.ac.in

MISSION & VISION STATEMENT OF INSTITUTE

Vision Statement

To be one of the leading technical institutes disseminating globally acceptable education, effective industrial training and relevant research output

Mission Statement

To be a globally accepted centre of excellence in technical education catalysing absorption, innovation, diffusion and transfer of high technologies resulting in enhanced quality for all stakeholders

MISSION & VISION STATEMENT OF THE DEPARTMENT

Vision Statement

Department of Mechanical Engineering, Sardar Vallabhbhai National Institute of Technology, Surat perceives to be globally accepted centre of quality technical education based on innovation and academic excellence.

Mission Statement

Department of Mechanical Engineering, Sardar Vallabhbhai National Institute of Technology, Surat strives to disseminate technical knowledge to its under graduate students, post graduate students and research scholars to meet intellectual, ethical and career challenges for sustainable growth of humanity, nation and global community.

PROGRAM EDUCATIONAL OBJECTIVES (PEO)

The Program of M. Tech. (Turbomachines) will produce graduates who will be able to:

PEO1	Create value to organizations through the analysis, evaluation and improvement of turbomachinery systems using appropriate analytical, experimental and computational tools.
PEO2	Design solutions for complex turbomachinery problems and design system that meet the specified needs like energy and pollution abatement.
PEO3	Apply turbomachinery concepts to address technical and societal problems with creativity, imagination, confidence and ethics
PEO4	Inculcate self-learning skills and communication skills towards overall personality development of the student

PROGRAM ARTICULATION MATRIX

Department Mission	**Mapping of PEO**			
	PEO1	**PEO2**	**PEO3**	**PEO4**
Department of Mechanical Engineering, Sardar Vallabhbhai National Institute of Technology, Surat strives to disseminate technical knowledge to its under graduate students, post graduate students and research scholars to meet intellectual, ethical and career challenges for sustainable growth of humanity, nation and global community.	**3**	**3**	**2**	**3**

PROGRAM OUTCOMES (PO)

The graduates of M. Tech. (Manufacturing Engineering) will demonstrate an ability to:

PO1	Carry out independent research /investigation and development work to solve practical problems
PO2	Write and express a substantial technical report/document
PO3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PSO1	Apply the mechanical engineering concepts to model, design, analyse and realize turbomachinery systems, components and processes.
PSO2	Assess the performance of turbomachinery systems using computational and experimental techniques.

COURSE STRUCTURE FOR M. TECH. –I (TURBOMACHINES)

SEMESTER – I

Sr. No	Subject	Code No.	Scheme L-T-P	Exam Scheme Th. Marks	T Marks	P Marks	Total	Credits	Notional hours of Learning (Approx.)
1.	**Core - 1** Advanced Fluid Dynamics	METM101	3-1-0	100	25	-	125	4	70
2.	**Core - 2** Thermodynamics and Heat Transfer for Turbomachines	METM103	3-1-0	100	25	-	125	4	70
3.	**Core-3** Jet and Rocket Propulsion	METM105	3-1-0	100	25	-	125	4	70
4.	**Core Elective – 1**		3-0-0	100	-	-	100	3	55
	1. Applied Gas Dynamics	METM111							
	2. Energy and Exergy Analysis of Turbomachines	METM113							
	3. Atomization and Sprays	METM115							
	4. Hydrodynamic Stability	METM117							
	5. Nonlinear Dynamics and Chaos	METM119							
5.	**Core Elective – 2**		3-0-0	100	-	-	100	3	55
	1. Finite Element Methods in Thermal Systems	METM121							
	2. Measurements and Data Analysis	METM123							
	3. Rotodynamic Pump and Pumping System	METM125							
	4. Unconventional Turbomachines	METM127							
	5. Rotor Dynamics, Vibration And Stress Analysis	METM129							
6.	Computational and Experimental Laboratory – I	METM107	0-0-6	-	-	150	150	3	110
Tota1				**500**	**75**	**150**	**725**	**21**	**430**
7.	Vocational Training/ Professional Experience *(Optional)(Only for PG Diploma in TM/Exit)*	METMV01 METMP01	0-0-10				5	5	200 (20 × 10)

SEMESTER – II

Sr. No.	Subject	Code No.	Scheme L-T-P	Exam Scheme Th. Marks	T Marks	P Marks	Total	Credits	Notional hours of Learning (Approx.)
1.	**Core – 4** Design of Turbomachines	METM102	3-1-0	100	25	-	125	4	70
2.	**Core - 5** Combustion for Propulsion Systems	METM104	3-0-0	100	25	-	125	3	55
3.	**Core Elective - 3**		3-0-0	100	-	-	100	3	55
	1. Micro-Hydro Power Plant	METM130							
	2. Theory and Design of Cryogenic Systems	METM132							
	3. Cascade Aerodynamics	METM134							
	4. Condition Monitoring and Fault Diagnosis of Rotating Machinery	METM136							
	5. Turbulent Combustion	METM138							
4.	**Core Elective – 4**		3-0-0	100	-	-	100	3	55
	1. Wind Energy Conversion System	METM140							
	2. Multi-phase Flows	METM142							
	3. Flow and Flame Diagnostics	METM144							
	4. Thermo-acoustic Instabilities	METM146							
	5. Machine Learning For Thermal Systems	METM148							
5.	**Institute Elective – I**		3-0-0	100	-	-	100	3	55
	1. Computational Fluid Dynamics	METM170							
	2. Hydrogen Energy Applications to Propulsion and Future Modes of Transport	METM172							
	3. Design of Reacting Systems	METM174							
	4. Turbulence and Turbulent Flows	METM176							
	5. Fundamentals of Solid Propellant and Multi-Phase Combustion	METM178							
6.	Computational and Experimental Laboratory – II	METM106	0-0-6	-	-	150	150	3	110
7.	Mini Project	METM108	0-0-4	-	-	100	100	2	70
Total				**500**	**50**	**200**	**800**	**21**	**470**
8.	Vocational Training/ Professional Experience *(Optional)(Only for PG Diploma in TM/Exit)*	METMV02 METMP02	0-0-10					5	200 (20 × 10)

SEMESTER – III

Sr. No.	Subject	Code No.	Scheme L-T-P	Exam Scheme			Total	Credits	Notional hours of Learning (Approx.)
				Th. Marks	T Marks	P Marks			
1.	**MOOC course - I**		-	-	-	-	-	3/4	70/80
2.	**MOOC course - II**		-	-	-	-	-	3/4	70/80
3.	Dissertation Preliminaries	METM295	-	-	-	350	350	14	560
Tota1				-	-	**350**	**350**	**20-22**	**700-720**

***** Students may choose any available MOOC courses from SWAYAM or NPTEL with the consent of their M.Tech. supervisor.

SEMESTER – IV

Sr. No.	Subject	Code No.	Scheme L-T-P	Exam Scheme			Total	Credits	Notional hours of Learning (Approx.)
				Theory Marks	Tuto. Marks	Pract. Marks			
1.	Dissertation	METM296	-	-	-	600	600	20	800

<u>Total Credits: 21 + 21 + 20-22 + 20 = 82-84 credits</u>

<u>Credit Matrix</u>

Category	Credit to be earned				
	Sem - I	Sem – II	Sem – III	Sem – IV	Total
Core Courses	12	07	-	-	19
Elective Courses	06	09	-	-	15
MOOC Courses	-	-	6-8	-	6-8
Software/Laboratory	03	03	-	-	06
Mini Project	-	2	-	-	02
Dissertation	-	-	14	20	34
Total Credits	21	21	20-22	20	**82-84**

METM101	:	ADVANCED FLUID DYNAMICS	L	T	P	Credits
			3	1	0	04

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Model fluid flow through complex domain
CO2	Analyse potential flow over circular cylinder
CO3	Evaluate the drag due to the boundary layer shear
CO4	Develop models for turbulent flows
CO5	Explore the fluid flow through rotating passages
CO6	Comprehend the concepts of swirling flows

2. Syllabus:

Governing Equations Of Fluid Motion	**(14 Hours)**
Lagrangian and Eulerian description, Reynolds transport theorem, Integral and differential forms of governing equations: mass, momentum and energy conservation equations, Cartesian Tensors, Stokes hypothesis for stress tensor, Navier-Stokes equations, Energy equation, Euler’s equation, Bernoulli’s Equation, Exact solutions of Navier-Stokes equations in Cartesian and cylindrical domain, Flow between concentric rotating cylinders, Parallel flow of a power law fluids, Stratified flow of two fluids, Fluid mechanics of different class of turbomachines with energy and angular momentum considerations.	
Potential Flows	**(6 Hours)**
Stream function and Velocity potential function, Circulation, Line vortex, Basic plane potential flows: Uniform stream; Source and Sink; Vortex flow, Doublet, Superposition of basic plane potential flows, Flow past a circular cylinder, Concept of lift and drag.	
Boundary Layer and Free Shear Layer Flows	**(8 Hours)**
Boundary layer behaviour and device performance, boundary layer equations for plane and curved surfaces, Von-Karman Momentum Integral Equation, Blasius solution, Boundary Layers with non-zero pressure gradient, separation and vortex shedding.	
Turbulence and Turbulent Flow Modeling	**(9 hours)**
Mechanism of turbulence, Kolmogorov scale, Kinetic energy of the mean flow and fluctuations, turbulent intensity, Reynolds Averaged Navier-Stokes (RANS) equations, Turbulent stresses, Eddy viscosity, Prandtl mixing length model, K-Epsilon model of turbulence, Universal velocity distribution law and friction factor, Concept of Large Eddy Simulations (LES) and Direct Numerical simulations (DNS).	
Flow in Rotating Passages and Swirling Flows	**(8 Hours)**

Rotating coordinate systems and Coriolis accelerations, Conserved quantities in a steady rotating flow, Phenomena in flows where rotation dominates (Non-dimensional parameters: the Rossby and Ekman numbers, Inviscid flow at low Rossby number: the Taylor–Proudman Theorem, Viscous flow at low Rossby number: Ekman layers), Swirling flows in radial equilibrium flows, Rankine vortex flow, waves on vortex cores, steady vortex core flows

(Total Lecture Hours: 45)

3. Books Recommended:

1	Schlichting H., "Boundary layer Theory", McGraw Hill, NY, USA, 2016.
2	Anderson Jr. John D., "Fundamentals of Aerodynamics", McGraw-Hill, NY, USA, 2010
3	Greitzer, E. M., Tan, C. S., Graf, M. B. "Internal Flow Concepts and Applications". Cambridge University Press, Cambridge, United Kingdom, 2007
4	Dixon S. L., "Fluid Mechanics Thermodynamics of Turbomachinery" Butterworth-Heinemann, Oxford, United Kingdom, 2013
5	White, Frank M., and Joseph Majdalani. Viscous fluid flow. Vol. 3. New York: McGraw-Hill, 2006.

METM103	:	THERMODYNAMICS AND HEAT TRANSFER FOR TURBOMACHINES	L	T	P	Credits
			3	1	0	04

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Calculate energy transfer, losses, and efficiency of the turbines.
CO2	Predict the performance of prototype using dimensional and similitude analysis
CO3	Express problems related to convection heat transfer in terms of mathematical equations and interpret their solutions in physical terms.
CO4	Solve radiative heat transfer between black and real surfaces, develop solutions for radiation heat transfer in participating mediums and get an overview of how to model gas radiation
CO5	Analyse the various hot spots of high temperature in turbine components
CO6	Comprehend the necessity of various turbine blade cooling techniques.

2. Syllabus:

Basic Thermodynamics of Turbomachines	**(12 Hours)**
Classification of turbomachines, Radial flow compressors — Energy transfer, Concept of Rothalpy, Isentropic efficiency, Effect of compressibility and pre-whirl, Diffuser, Non-dimensional parameters. Axial flow compressors — Energy Transfer, h-s diagram, Degree of reaction, Losses. Axial flow turbines (Impulse and Reaction) — stage work, Losses in turbines, Reheat factor and condition curve, constant stage efficiency, forms of actual condition curve, Turbine total wheel speed. Radial flow turbine —Radial Turbine Characteristics; Losses and efficiency, estimation of stage performance in outward-Flow Radial turbines. Thermodynamic properties of fluids, Compressible flow relationships, Concept of Polytropic efficiency, Dimensional Analysis – Similitude.	
Heat Transfer	**(20 Hours)**
Fundamentals of Heat Transfer Heat transfer terms in basic and tensor forms of governing equations. Conduction: General three-dimensional heat conduction equation in Cartesian, cylindrical & spherical coordinates, Initial condition and various boundary conditions. Convection: Free & Forced convection. Similarity & Simulation of convection heat transfer, Boundary layer theory. Laminar internal and external flow heat transfer, Turbulent flow heat transfer. Analogy between momentum &heat transfer. Heat transfer in high velocity flow. Natural convection under different situations. Radiation : Radiation Heat Exchange between surfaces —Gas Radiation —Equivalent beam length, Enclosure theory in the presence of a radiating gas, Radiative Transfer Equation, General and Exact solution of RTE, Isothermal gas enclosures, Well-stirred furnace model, Gas radiation in complex enclosures, Interaction between radiation and other modes of heat transfer.	

Applications of Heat Transfer	(06 Hours)
Turbine Heat Transfer: Turbine-stage heat transfer, cascade vane heat transfer, cascade blade heat transfer, airfoil endwall heat transfer, contouring and its measurements, turbine rotor blade tip and casing heat transfer, leading edge region heat transfer and its modifications for reducing secondary flows, flat surface heat transfer, deposition and surface roughness effects on heat transfer, combustor-turbine effects, transition-induced effects and modelling.	
Turbine Blade Cooling	**(07 Hours)**
Effect of High gas Temperature, Cooling techniques, Convective cooling — Internal Heat transfer in stationary and rotating blades, External Heat transfer, Film cooling — Adiabatic Film cooling effectiveness, HTC, analysis of single and multiple film cooling, Full-coverage film cooling, effect of various parameters on film cooling. Transpiration cooling, Aerodynamics, losses and efficiency of cooling. Heat exchange in cooled blade, ideal cool stage and actual cool stage, discrete three dimensional jets, thermal turbulence modeling techniques and transport equations, experimental methods for thermal parameters including liquid crystal thermography on the rotating surfaces of turbomachinery.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Cohen, Longman, R. “Theory of gas turbines “Pearson, London, UK, 2017.
2	Ganesan V.., “Gas Turbines”, Tata McGraw Hill Education (India) Private Limited, 2017.
3	Dixon, S. L. and Hall, C. A., “Fluid Mechanics and Thermodynamics of Turbomachinery”, Elsevier Publisher, USA, 2014.
4	Srinath E, Dutta S. “Gas Turbine Heat Transfer and Cooling Technology”, CRC press, Australia, 2012
5	Incropera & Dewitt, “Fundamentals of Heat and Mass Transfer”, John Wiley, USA, 2011.

METM105	:	JET AND ROCKET PROPULSION	L	T	P	Credits
			3	**1**	**0**	**04**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Illustrate various types of jet systems and understand difference between air breathing and non-air breathing engines.
CO2	Analyze the thermodynamics cycles and performance parameters of air breathing systems
CO3	Demonstrate rocket propulsion theory and discuss classifications of rockets
CO4	Illustrate rocket nozzle types and their flow behavior at design and off-design conditions.
CO5	Analyse the performance parameters of rocket propulsion systems
CO6	Explain types of chemical rockets and details of its propellant

2. Syllabus:

Introduction	**(09 Hours)**
Introduction of gas turbine cycle and various components of gas turbine engine, Introduction of jet propulsion systems, Computation of stagnation properties, Basic components of air breathing engines, Inlet ducts for aircraft gas turbines, Brief idea about compressor, combustion chamber, turbine, and aircraft nozzles, Classification of propulsive device, types of rocket engines, application of rocket engines. Non-chemical rocket engines: Electric propulsion, Nuclear rocket engines, Solar Energy rockets.	
Air Breathing Engines	**(06 Hours)**
Performance parameters for air breathing engine (Thrust, Efficiency, Aircraft Range, Take-off Thrust, Specific Fuel Consumption), Basic gas generator & its variations, Turbojet, Turboprop, Turbofan, Pulse jet, Ram jet, Scramjet, Thrust Augmentation.	
Parametric Cycle Analysis of Air Breathing Gas Turbine Engines	**(09 Hours)**
Parametric Cycle Analysis of Ideal Turbo Jet Engine, Real Turbojet Cycle, Analysis of Turbofan Engine, Analysis of Turbofan Engine, Analysis of Turboprop Engine, Ramjet & Scramjet Engine.	
Rocket Performance Parameters	**(06 Hours)**
Laws of thermodynamics, combustion parameters, rudiments of gas dynamics, Ideal rocket performance, thrust equation, Total impulse and Specific Impulse, Specific impulse efficiency, volume specific impulse, impulse-to-weight ratio, energy balance, efficiencies and coefficients of rocket engines.	
Nozzles for Rocket Engines	**(03 Hours)**

Rocket nozzles; expansion of gases from high-pressure chamber. Convergent divergent nozzle, choking and variation of parameters in nozzle. Expansion ratio of nozzles and performance loss in nozzles. Under-expanded and over-expanded nozzles. Losses and performance analysis of rocket engines.	
Rocket Propellants and Engines	**(12 Hours)**
Classification of Chemical propellants, Solid propellants, Liquid propellants, Gel Propellants and Hybrid Propellants. Solid-propellant rocket engines—Burning mechanism, Propellant Burning and regression rates, Propellant grain configuration, Ignition system. Liquid-propellant rocket engines—Classification of engines, Combustion of Liquid Propellants, Combustion chamber geometry, Ignition systems, cooling systems, Hybrid-propellant rocket engines— combustion chamber, grain configuration, Ignition of hybrid propellants	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Ganesan V.., "Gas Turbines", Tata McGraw Hill Education (India) Private Limited, 2017.
2	Venkanna B. K. , "Fundamentals of Turbomachinery", PHI, India, 2010
3	Mattingly, J. D., "Elements of gas turbine propulsion", Tata McGraw-Hill Edition, NY, USA, 2005.
4	Jack D. Mattingly, "Elements of Propulsion: Gas Turbines and Rockets," AIAA Publication, USA, 2016.
5	Sutton, G. P. and Biblarz O., "Rocket propulsion elements" Wiley Publications, USA, 2016.
6	Mukunda H. S., "Understanding aerospace propulsion," Interline Publishing, Bengaluru, India, 2017.

METM111	:	APPLIED GAS DYNAMICS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Predict the effect of compressibility and flow behaviour in the field of gas dynamics
CO2	Solve 1-D design problems for Isentropic flow in variable area passages
CO3	Analyse compressible flow with normal shock
CO4	Model flow with heat transfer and friction
CO5	Apply gas dynamics concepts to propulsion systems
CO6	Describe the equipment and its arrangement to carry out measurements in compressible fluid flows.

2. Syllabus:

Introduction	**(03 Hours)**
Thermodynamics of compressible flow, Compressibility of Fluids, Compressible and incompressible flows, Perfect gas equation of state, Calorically perfect gas, Acoustic wave propagation speed: Mach number, Reference states: Sonic state and Stagnation state, T-s and P-v diagrams in compressible flows.	
One-Dimensional, Steady, Isentropic Flow in Variable Area Passages	**(04 Hours)**
Introduction, governing equations, Effect of area change in the fluid properties, Equations for Isentropic flow, Geometric choking, Area Mach number relation for choked flow, Maximum mass flow rate, Flow through nozzles and diffusers.	
Normal Shock	**(05 Hours)**
Governing equations, classification of shock, Normal shock solution, Rankine Hugoniot Relations, Normal shock solution on T-s and P-v diagram	
Flow with Heat Transfer	**(05 Hours)**
Governing equations, Slope of Rayleigh line on p-v diagram, Fundamental equation of Rayleigh line, Maximum heat transfer, thermal chocking and its consequences.	
Flow in Constant area Duct with Friction	**(05 Hours)**
Governing equations, Illustration on T-s diagram, Fanno flow equations, Variation of Mach number with duct length, Friction choking and its consequences.	
Two-Dimensional Flows	**(06 Hours)**
Oblique shock wave and its governing equations, θ-B-M relations, Supersonic flow over wedges Mach line, Attached and Detached shock, Reflections and interaction of oblique shock waves, Mach Reflection, Expansion waves, Prandtl-Meyer flow and its governing equations, Supersonic flow over convex and concave corners.	

Application of Gas Dynamics to Propulsion Systems	**(09 Hours)**
Introduction to Beltrami flows - Axisymmetric Beltrami flows, Mass flow rate through annulus - Chocking of flow through annulus. Brayton Cycle, Propulsion Engines, Flow Through Inlets, Air-breathing propulsion systems performance parameters and Rocket propulsion systems performance parameters.	
Measurements in Compressible Flows	**(08 Hours)**
Compressible flow visualization, High-speed wind tunnels, Measurement of thermodynamic properties in high speed flows.	

(Total Lecture Hours: 45)

3. <u>Books Recommended:</u>

1	Rathakrishnan, Ethirajan. "Applied gas dynamics." Wiley, USA, 2019.
2	Anderson, J.D., Jr., “Modern Compressible Flow”, Tata McGraw Hill Education Private Limited, Third Ed.,NY, USA, 2012.
3	Zucker, Robert D., and Oscar Biblarz. “Fundamentals of gas dynamics”. John Wiley & Sons, USA, 2019.
4	S.M. Yahya, Fundamental of Compressible Flow with Aircraft & Rocket Propulsion, New Age International Ltd., 2016
5	E. Rathakrishnan, Gas Dynamics, PHI Learning Pvt. Ltd., India, 2017

METM113	:	ENERGY AND EXERGY ANALYSIS OF TURBOMACHINERY SYSTEMS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Model the thermal and turbomachines as well as integrated systems based on energy analysis
CO2	Calculate the exergy and perform exergy balances for thermodynamic systems
CO3	Model exergy transfer and exergy losses in thermal and turbomachinery systems
CO4	Evaluate exergy analysis of integrated systems
CO5	Model the of steam power plants and turbomachines based on exergy analysis
CO6	Apply energy analysis concepts to turbomachines integrated systems

2. Syllabus

Energy Analysis	**(06 Hours)**
Application of First law of thermodynamics to turbines, compressors, and pumps, Thermal power plant, Gas turbine plants, Cogeneration and combined cycle plants and Turbomachines integrated with other systems.	
Exergy Concepts	**(12 Hours)**
Second Law of Thermodynamics, High grade and low grade energy, Difference between energy and exergy, Classification of forms of exergy, Physical exergy, Chemical exergy, Exergy concepts for a control region, Exergy concepts for closed system analysis. Pictorial representation of exergy balance, Exergy-based property diagrams.	
Exergy Analysis for Various Processes	**(06 Hours)**
Exergy analysis for Expansions process, Compression processes, Heat transfer process, Mixing and separation Process, Chemical process mainly combustion.	
Energy Analysis of Turbomachines	**(12 Hours)**
Exergy analysis of Gas and steam turbine, hydraulic turbines, Compressors, Nozzles, Exergy analysis of a turbojet (exergy flow through a turbojet, exergy efficiencies of a turbojet, cumulative exergy loss, breakdown of exergy of emission, environmental impact and sustainability.	
Energy Analysis of Turbomachine Integrated Systems	**(09 Hours)**
Introduction to systems of steam power plant, balance equations of exergy, exergy values, process description, exergy efficiency, simplified process diagrams, exergy losses, environmental impact and sustainability.	

(Total Lecture Hours: 45)

3. **Books Recommended:**

1	Kotas T.J., "The Exergy Methods of Thermal Plant Analysis", Krieger Publ. Corp. USA, 2013.
2	Yahya S. M., "Turbines, Compressors and Fans" Tata McGraw Hill, New Delhi, India, 2010
3	Dixon S.L. and Hall C.A. "Fluid Mechanics and Thermodynamics of Turbomachinery", Butterworth-Heinemann (Sixth Edition), Oxford, England, 2010
4	Turner, W.C., (Ed.), "Energy Management Handbook", John Wiley & Sons, N.Y., USA, 2002.
5	Ibrahim D, Marc A. R. "Exergy – Energy, Environment and sustainable Development", Elsevier, Netherlands, 2021.

METM115	:	ATOMIZATION AND SPRAYS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Illustrate theory of atomization and evaporation
CO2	Model jet breakup and drop formation theoretically
CO3	Explain the application of multiphase models for studying spray transport
CO4	Design spray nozzle and atomizers and discuss potential applications in combustion systems
CO5	Describe experimental evidence in support of theoretical models of drop formation and atomization
CO6	Apply spray models and perspective simulations to realistic gas turbine engines

2. Syllabus:

Introduction	**(03 Hours)**
Atomizers, Factors influencing atomization, Spray characteristics, Applications.	
Drop Size Distribution of Sprays	**(04 Hours)**
Number distributions, Mass/volume distributions, Empirical distributions, Theoretical distributions.	
Basic Process in Atomization	**(08 Hours)**
Sheet and ligament breakup —Instability analyses for ligaments and sheets, Design models based on instability analyses. Drop formation—Static and dynamic force balances, Continuity considerations, Secondary atomization, Collisions and coalescence.	
Drop Motion and Spray-Surroundings Interactions	**(04 Hours)**
Steady trajectories (gas turbines, spray cooling, paint sprays), Entrainment.	
Drop Evaporation	**(03 Hours)**
Steady evaporation, Unsteady evaporation, Convective effects.	
Internal and External Fluid Mechanics	**(05 Hours)**
Atomization models, Swirl atomizers, Impinging jet atomizers, flash sprays, supercritical and trans-critical injection, evaporating sprays, reacting sprays, spray group combustion, droplet evaporation in the non-continuum regime, droplet freezing and solidification, numerical techniques for simulating the atomization process, modelling atomization using boundary element methods, continuum-based methods for spray, lattice Boltzmann method for sprays, spray-wall impact, interacting sprays., Cone angle, Radial and circumferential mass flux distributions	
Atomizers	**(06 Hours)**

Flow in Atomizers, Spray Nozzles, drop on demand drop generators, droplet stream generator, plain orifice spray nozzles, pintle injectors, atomization of a liquid jet in a crossflow, impinging jet atomization, splash plate atomizers, electrosprays, swirl, T-jet and vibration-mesh atomizers, Modern design models for pressure-swirl atomizers, impinging jet atomizers, transient pressure (Diesel) atomizers.	
Measurement Techniques	**(06 Hours)**
Drop sizing by Malvern and P/DPA, Drop velocity by P/DPA, Mass flux distribution via patternators and P/DPA.	
Spray Applications	**(06 Hours)**
Spray applications in Internal Combustion Engines, Spray Modelling and Predictive Simulations in Realistic Gas-Turbine Engines, Melt Atomization, Spray Drying, Spray Pyrolysis, Spray Freeze Drying, Low-pressure Spray Pyrolysis, Flame Spray Pyrolysis, Particle production via. Emulsion combustion spray method, Pharmaceutical aerosol spray for drug delivery to the lungs, fire suppression.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Lefebvre, A.H. and McDonell, V. G. “Atomization and Sprays,” CRC Press, 2017
2	Bayvel, L. and Orzechowski Z. “Liquid Atomization,” Routledge, Taylor and Francis: Washington DC, USA, 2019.
3	Ashgriz N., “Handbook of atomization and sprays: theory and applications,” Springer Science & Business Media, Heidelberg, Germany, 2011.
4	Nasr GG, Yule AJ, Bendig L., “Industrial sprays and atomization: design, analysis and applications” Springer Science & Business Media, Heidelberg, Germany, 2013.
5	Ashgriz N., Yarin A. L., “Handbook of Atomization and Spray – Theory and Applications”, Springer, Heidelberg, Germany, 2011.

METM117	:	HYDRODYNAMIC STABILITY	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the concept of stability of fluid flows
CO2	Identify indicators and metrics of instability
CO3	Analyse the stability of hydrodynamic systems
CO4	Evaluate the influence of real-world, engineering conditions on flow stability
CO5	Explain a working knowledge of current analytical and numerical techniques to characterize hydrodynamic instability
CO6	Apply numerical techniques to characterize hydrodynamic instability

2. Syllabus:

Introduction	**(4 Hours)**
Methods of Hydrodynamic stability, Temporal and Spatial Instability, Bifurcation, Stability and Linearized Problem, generalized solutions in hydrodynamic stability, branching and stability of solutions of the Navier-Stokes equation, Nature of turbulence, influence of presence of a porous medium on hydrodynamic stability	
Instability Mechanisms	**(6 Hours)**
Dynamic Stability of Still Atmosphere, Kelvin–Helmholtz Instability — Description of Instability, Equations for Perturbations, Surface and internal gravity waves, Rayleigh-Taylor Instability, Shear driven instability. Capillary Instability — Rayleigh' theory.	
Rayleigh-Benard Convection	**(5 Hours)**
Thermal convection, linearized problem, stability characteristics, Nonlinear Convection.	
Centrifugal Instability	**(5 Hours)**
Coordinate system, 2D and 3D disturbances, Axisymmetric disturbances, Taylor Problem, Dean Problem, Swirling Flows, Instability of Couette Flow, Gortler Instability, Pipe flow, rotating disk, trailing vortex, round jet.	
Instability and Transition in Flows	**(8 Hours)**
Parallel Flow Approximation and Inviscid Instability Theorems—Inviscid Instability Mechanism. Viscous Instability of Parallel Flows— Eigenvalue Formulation for Instability of Parallel Flows, Temporal and Spatial Amplification of Disturbances. Properties of the Orr–Sommerfeld Equation and Boundary Conditions, Instability Analysis from the Solution of the Orr–Sommerfeld Equation, Receptivity Analysis of the Shear Layer, Nonparallel and Nonlinear Effects on Instability and Receptivity.	

Nonlinear Effects: Multiple HOPF Bifurcations and Proper Orthogonal Decomposition	**(8 Hours)**
Receptivity of Bluff-Body Flows to Background Disturbances, Numerical Simulation of Flow Past a Cylinder, Multiple Hopf Bifurcations, Landau Equation and Flow Instability, Instability of Flow Past a Cylinder, Role of FST on Critical Reynolds Number for a Cylinder, POD Modes and Nonlinear Stability, Landau–Stuart–Eckhaus Equation, Universality of POD Modes.	
Stability and Transition of Mixed Convection Flows	**(5 Hours)**
Schneider's Similarity Solution, Linear Spatial Stability Analysis of the Boundary Layer over a Heated Plate, Nonlinear Receptivity of Mixed Convection Flow over a Heated Plate	
Instabilities of Three-Dimensional Flows	**(4 Hours)**
Linear Stability Theory for Three Dimensional Flows, Stability of the Falkner–Skan–Cooke Profile, Stationary and Travelling Waves Over Swept Geometries, Stability of the Falkner Skan–Cooke Profile.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Drazin P. G., "Introduction to Hydrodynamic Stability," Cambridge, England, 2002.
2	Charru F., "Hydrodynamic Instabilities," Cambridge, England, 2011.
3	Schmid P. and Henningson D., Stability and Transition in Shear Flows, Springer, USA 2001.
4	Sengupta T.K. "Instabilities of flows and transition to turbulence." Taylor & Francis; England, 2012.
5	Chandrasekhar S., "Hydrodynamic and Hydromagnetic Stability," Oxford, England, 2013.

METM119	:	NONLINEAR DYNAMICS AND CHAOS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Identify fixed points and determine their stability
CO2	Analyze the various types of bifurcations in one dimension and two dimension
CO3	Construct bifurcation diagrams and stability diagrams
CO4	Construct phase portraits and find basins of attraction
CO5	Analyze limit cycles and their stability
CO6	Apply time series analysis in rotating fluid flow systems

2. Syllabus:

One-Dimensional Systems and Elementary Bifurcations	**(05 Hours)**
Fixed points and stability, Linear stability analysis, existence and uniqueness, potentials, Saddle-node bifurcation, Transcritical bifurcation, Pitchfork bifurcation, Imperfect bifurcation, uniform and non-uniform oscillator.	
Two-Dimensional Systems; Phase Plane Analysis, Limit Cycles, POINCARÉ-BENDIXSON Theory	**(06 Hours)**
Classifications of linear systems, Phase portraits, existence, uniqueness and topological consequences, fixed points and linearization, conservative and reversible systems, Ruling out closed orbits, Poincaré-Bendixson theorem, Linear systems, Relaxation oscillators, Weakly nonlinear oscillators.	
Nonlinear Oscillators, Qualitative And Approximate Asymptotic Techniques, HOPF Bifurcations	**(06 Hours)**
Saddle-Node, Transcritical, and Pitchfork Bifurcations, Hopf Bifurcations, Global Bifurcations of Cycles, Coupled Oscillators and Quasiperiodicity.	
Lorenz and Rossler Equations, Chaos, Strange Attractors And Fractals	**(09 Hours)**
Lorenz Equation properties, Chaos on a strange attractor, Lorenz map, chaos application to send secret message, Fixed points and Cobwebs, Logistics Map: Numeric and Analysis, Periodic windows, Liapunov Exponent, Universality and experiments, Renormalization, Countable and uncountable sets, Cantor set, Dimension of self-similar fractals, Box dimension, Pointwise and Correlation Dimensions, Henson Map, Rosseler system, Forced double- well oscillator.	
Mappings of Systems	**(09 Hours)**
Iterated mappings, period-doubling, chaos, renormalization, universality, Hamiltonian systems; complete integrability and ergodicity, Area preserving mappings, KAM theory, Floquet theory, Infinite Dimensional Hamiltonians, On-Off Dissipative Systems.	

Non-Linear Dynamics in Turbomachinery Components	(04 Hours)
Thermo-fluid dynamic equations, time dependent equations of continuity, motion and energy, numerical treatment, Non-linear Gas Turbine dynamic Simulation.	
Chaos in Rotating Fluid Flow System	**(06 Hours)**
Theoretical models of transition to turbulence, spherical Couette flow, Taylor-Couette flow, rotating annulus heated from within, methods of time series analysis, route into chaos in the spherical Couette flow, route into chaos in the Taylor-Couette flow, time series analysis of Rossby waves.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Strogatz, Steven H. "Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering". Westview Press, United States, 2018.
2	Wiggins, S. "Introduction to Applied Nonlinear Dynamical Systems and Chaos". Springer, Berlin, Germany, 2006.
3	Drazin, P. G. "Nonlinear Systems" Cambridge University Press, Cambridge, United Kingdom, 2012.
4	Peitgen, H-O, H. Jurgens, and D. Saupe. Chaos and Fractals: New Frontiers of Science. Springer, Berlin, Germany, 2012.
5	Parker, T. S., and L. O. Chua. "Practical Numerical Algorithms for Chaotic Systems" Springer, Berlin, Germany, 2012.

METM121	:	FINITE ELEMENT METHOD IN THERMAL ENGINEERING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Develop weighted residual methods
CO2	Classify the concepts of Nodes and elements
CO3	Apply finite element modelling techniques for 1-D problems.
CO4	Build finite element modelling techniques for 2-D problems.
CO5	Formulate and solve fluid and heat transfer problems using FEM
CO6	Extend the FEM to transient problems.

2. Syllabus:

Introduction to Finite Element Method	**(03 hours)**
General introduction to finite element method, Types of analysis methods, Boundary Information, Initial Value Problem, Boundary Value Problem, Numerical methods, Direct Finite Element Method, Minimum potential energy method, weighted residual method: Co-location method, Sub-domain method, Least-Square method, Galerkin method and Methods of moments.	
One-Dimensional analysis	**(12 hours)**
Solution of second-order linear model boundary value problem: Discretisation of the domain, 1-D Iso-parametric element, weak form development, Lagrange interpolation functions: linear and quadratic, elemental response, Connectivity of elements, Assembly of elemental responses. Incorporation of boundary conditions, solution for unknown: elimination and penalty approach. Application to 1-D Heat Transfer: with and without heat generation and constant and variable cross-section. 1-D Fluid flow analysis.	
Two Dimensional Analysis	**(09 hours)**
Two-dimensional steady-state heat conduction equation, Triangular elements, development of elemental stiffness matrix and load vector, Assembly of elemental response. Solution of 2-D heat conduction problem with and without heat generation.	
Dynamic Analysis	**(09 hours)**
1-D transient heat conduction in pin-fin: derivation of the fundamental equation in matrix form, assembly of elements, solution using the trapezoidal rule. Stability Analysis. Solution of Transient temperature distribution along the length of the pin fin.	
Coupled Boundary Value Problems: Heat Transfer and Fluid Mechanics	**(12 hours)**

Convection Heat Transfer, Governing Equations, Non-Dimensional Form of Governing Equations, Convection-diffusion problem, Finite element solution to the steady and transient convection-diffusion problem: Laminar heat transfer, Forced convection, Buoyancy-driven convective heat transfer, and mixed convection.

(Total Lecture Hours: 45)

3. <u>Books Recommended:</u>

1	Logan, D. L., A first course in the finite element method, Cengage Learning, UK, 2012.
2	Rao S. S., Finite element method in engineering, Pergaman Int. Library of Science, UK, 2013.
3	Frieswell M.I., et al. Dynamics of Rotating Machines, Cambridge university press, England 2015
4	Reddy J.N., Finite Element Method, McGraw -Hill International Edition, NY, USA, 2007.
5	Seshu P., Finite Element Analysis, PHI learning Pvt. Ltd., New Delhi, 2012.

METM123	:	MEASUREMENTS AND DATA ANALYSIS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Recognize the basic concepts of measurement systems
CO2	Evaluate error and uncertainty analysis of thermal system
CO3	Execute the working principles of various instruments used to measure the flow properties.
CO4	Demonstrate the measurement of flow angle and torque of turbomachines
CO5	Illustrate the operational details and interpret the data obtained by the measurement techniques
CO6	Analyse data using data post-processing techniques

2. Syllabus:

Characteristics of Measurement Systems	**(06 Hours)**
Need of Experiments, design of experiments, calibration, sensitivity and error analysis, uncertainty analysis, Response characteristics of instruments-1st & 2nd order instruments	
Measurement of Flow Properties & Flow Visualization	**(15 Hours)**
Pressure measurement, temperature measurement, velocity measurement (obstruction type, variable area, anemometry, LDV), shadow-graphy, Schlieren method, background-oriented Schlieren, Interferometry, modern flow visualization techniques, image processing, particle image velocimetry.	
Measurement of Flow Angle and Torque of Turbomachines	**(06 Hours)**
Measurement of pitch angle, measurement of torque by dynamometer, strain gauge and transducer.	
Data Processing and Analysis	**(18 Hours)**
Statistical analysis of experimental data – statistical principles, stationary random processing, estimator expectation and variance, probability, rejection of data: Chauvenets Criterion with example, error propagation: function of two variables, several variables, The methods of least square, linear regression analysis, gauge R & R, fundamentals of data Processing – Fourier Transform, correlation function, Hilbert Transform, proper orthogonal decomposition, conditional averages and stochastic estimation, wavelet transforms ,and imaging detectors	

(Total Lecture Hours: 45)

3. **Books Recommended:**

1	Holman J. P., “Experimental methods for engineers”, McGraw Hill, NY, USA, 2017.
2	Doebelin E.O. and Manik D. N. “Measurement systems: application and design”, Mc. Graw Hill, NY, USA, 2019.
3	Venktesh S. P. “Mechanical measurements”, John Wiley & Sons Ltd, USA, 2021.
4	Goldstein R. “Fluid mechanics measurements,” Taylor & Francis, USA, 2017.
5	Sheldom M. R., “Introduction to probability and statistics for engineers and scientist”, Elsevier, Fifth Edition, Amsterdam, Netherland, 2014.

METM125	:	ROTODYNAMIC PUMP AND PUMPING SYSTEM	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the concepts of rotodynamic pumps and the classification of the rotodynamic machines
CO2	Understand the basic theory and construction of centrifugal pumps, their characteristics, and their common terminology
CO3	Learn about mixed and axial flow pumps and analyze their performance characteristics
CO4	Understand and analyze pump operation, range for multiple pump systems, and protection strategies
CO5	Evaluate the performance of the pump in a piping system and understand various flow regulation methods for process control
CO6	Apply the knowledge of fluid machinery and learn about the special applications of pumps

2. Syllabus:

Introduction	**(06 Hours)**
Principle and Classification of Pumps, Basic Parameters of Pump, Pump Construction, Losses in Pumps and Efficiency, Similarity Laws in Pumps.	
Centrifugal Pumps	**(12 Hours)**
Overview of centrifugal pump, construction and working, Energy equation and its importance, flow physics in centrifugal pump, velocity triangles, performance characteristics and system characteristics of centrifugal pump, slip factor, Axial and radial thrust, priming, cavitation in pumps, NPSH required and NPSH available, specific speed of the pump, series and parallel arrangement of a pump.	
Mixed and Axial Pump	**(08 Hours)**
Overview of mixed and axial flow pumps, Construction and operating principles, velocity triangles, performance characteristics, and applications.	
Integration of Pumps and Piping System	**(10 Hours)**
Pump operating point and range of operation, system curve, single and branch pipe system, variable system curves, multiple pump systems, water hammer, and protection.	
Capacity Regulation of Pump in Piping System	**(06 Hours)**
Throttle regulation, regulation with bypass, speed regulation and proportional pressure control, constant pressure control, and constant temperature control.	
Special Applications of Pumps	**(03 Hours)**
Pumps used in mines and other systems for special purpose	

(Total Lecture Hours: 45)

3. **Books Recommended:**

1	Jagdish Lal, Hydraulic Machines including Fluidics, Metropolitan Book Company, 2016.
2	S. K. Som, G. Biswas, S. Chakraborty, Introduction to Fluid Mechanics and Fluid Machines, McGraw Hill, 2017
3	Gülich, J.F. Centrifugal Pumps; Springer International Publishing: Cham, Switzerland, 2020
4	Srinivasan, K. M. Rotodynamic pumps (centrifugal and axial). Second edition, New Age International, 2018.
5	Charles C. Heald, Igor J. Karassik, Joseph P. Messina, Paul Cooper; Pump Handbook, 4th Edition, McGraw Hill Publications 2008

METM127	:	UNCONVENTIONAL TURBOMACHIERY	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Analyse wind resource and energy production for a wind turbine from wind speed distribution and wind shear
CO2	Examine and should be able to design a unconventional turbomachines
CO3	Illustrate and value diverse approaches to solving critical problems in new frontiers of research and creating new knowledge judged by international standards
CO4	Explain the unconventional power plants while extending knowledge to economics and environmental aspects.
CO5	Evaluate the importance of integration of power plants
CO6	Elucidate recent advances in unconventional turbomachines

2. Syllabus:

Wind Turbines	**(14 Hours)**
Wind resources —The nature of wind, Geographical variation in wind resources, Long term wind speed variations, Turbulence, Extreme wind speed, Turbulence in wakes and Wind farms. Aerodynamics of Horizontal Axis Wind Turbine —Introduction, Actuator disc concept, Rotor disc theory, Vortex cylinder model of the actuator disc, Rotor blade theory, Breakdown of momentum theory, blade geometry, The effect of discrete number of blades, calculated results for an actual turbine. Wind Turbine Performance —The performance curves, constant rotational speed Operation, Comparison of measured with theoretical performance, variable speed operation, Estimation of energy capture, Wind turbine performance measurement, Aerodynamic Performance measurement**.** Conceptual Design of Horizontal Axis Wind Turbine —Introduction, Rotor diameter, Machine rating, Rotational speed, number of blades, Power control, Braking system, Fixed Space, Two Speed or variable speed operation, Type of generator. Component Design —Blades, Pitch bearings, Rotor Hub, Gearbox, Generator, Mechanical Brake, yaw drive, Tower, Foundations	
Solar Turbines	**(06 Hours)**
Elements of solar power plants, solar collectors, solar receivers, solar energy storage, solar ponds, solar turbines	
Geothermal Power Plants	**(06 Hours)**
Technology Applied in Turbines for Geothermal Plants, Recent Technologies for Geothermal Steam Turbines, Optimal design of geothermal power plants, Small Geothermal Power plants, Design performance and Economics.	
Micro – Turbine Generators	**(05 Hours)**

Introduction to Micro-Turbine Generators, Analysis of Micro and Mini Turbine, Design reliability, Design Problems in Micro-turbine Generators, Tip leakage flow in Axial and Radial Turbines.	
Tesla Turbine	**(05 Hours)**
Operating principle, Description of Tesla's Flat Disk Turbine, Rotor, Stator, Stator end support, bearings, bearing caps, retainers, inlet plumbing, nozzle details, stresses in the discs, performance calculations.	
Recent Advance in Unconventional Turbomachines	**(09 Hours)**
Supercritical mini CO2 turbine— Introduction to carbon dioxide turbines, design. organic Rankine cycle's turbine— Mini-ORC radial inflow turbine and ORC radial-outflow turbine stage. IGCC— Introduction, Major IGCC Blocks and Components: Gasification, Fuel types for use in IGCC systems, Syngas production and cooling, Syngas cleaning, separation of CO2 and hydrogen enrichment, Current status and future prospects for IGCC systems.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Duffie, J.A., and Bechman, "W. A., "Solar Engineering of Thermal Processes", John Wiley, N. Y., USA, 2013.
2	Maths, D. A., "Hydrogen Technology for Energy", Noyes Data Corp., New York, 2002.
3	Freris, L. L. "Wind Energy Conversion System", Prentice Hall, New Jersey, 2001.
4	Spera, D.A., "Wind Turbine Technology, Fundamental Concepts of Wind Turbine Engineering", ASME Press. N. Y., USA, 2001.
5	Twidell, J.W., and Weir, A.D., "Renewable Energy Resources", Taylor & Francis, New York, 2006

			L	T	P	Credits
METM129	**:**	**ROTOR DYNAMICS, VIBRATION AND STRESS ANALYSIS**	**3**	**0**	**0**	**03**

1. <u>Course Outcomes (COs):</u>

At the end of the course the students will be able to:

CO1	Design rotor blades
CO2	Analyze the transverse, torsional vibrations of rotors
CO3	Illustrate the dynamics of cracked shaft under vibrations
CO4	Explain the fundamental concepts of rotating machinery balancing
CO5	Evaluate the governing FE equations for solving vibration problems pertained to rotor systems
CO6	Apply finite element methods to rotor dynamics

2. <u>Syllabus:</u>

Stress Analysis of Rotors	**(09 hours)**
Stresses in Rotating discs and blade, disc of uniform strength, thermal stresses, blade design for strength, formulation of eigenvalues problem, Dunkerley's procedure, root-squaring process, application with dissipative and continuous systems.	
Vibration Analysis of Rotating Machinery	**(12 hours)**
Transverse vibration-Single, two and three rotor systems, Critical speeds of shafts, Torsional vibrations of rotors: One and two disc torsional rotor system, Three disc rotor system, Frequency of torsional vibration systems, Coupling of Torsional and bending vibrations due to Pre twist and eccentricity, rotor failure modes, forward and backward rotor whirl model, variable elasticity effects in rotating systems, flow induced vibration in rotating systems, Newkirk effect, dynamics of cracked shaft and identification by vibration analysis, thermal effects induced due to vibration of shaft.	
Rotating Machinery Balancing	**(15 hours)**
Rotor-bearing interactions. Fluid film bearings: Steady state characteristics of bearings. Rolling element bearings, Simple rotor bearing foundation systems and gyroscopic effects, Rotor-bearing interactions, influence of bearing support pedestal stiffness on rotor critical frequency, U-rotor mode, S-Rotor mode, rotor-bearing support pedestal modeling, testing methods, fluid-film, steam and gas seal influences on rotor dynamics. Instability in rotors, Sources of unbalance in rotors, Rigid and flexible rotors balancing, field balancing of turbine-tenerator trains, natural frequency, mode shapes and critical vibration, actual heavy spot angle, indicated heavy spot angle, balancing analysis, rotor train alignment.	
Finite Element Analysis in Rotor Dynamics	**(09 hours)**
Introduction to finite element methods-Finite element vibration analysis of simple rotor systems, orthogonality, Eigen Value problem, modal analysis, damped vibrations. Finite	

element analysis of rotors including gyroscopic effects, time domain solutions, frequency domain solutions, free vibration solutions, modal solutions, static condensation, dynamic reduction, lanczos method, orthogonal factorization, block lanczos method, solutions of periodic equation, frequency response with and without rotation, transient response with and without rotation, FE case studies of turbine wheel with shaft and blade, analysis of aircraft propeller.

(Total Lecture Hours: 45)

3. Books Recommended:

1	Rao J. S. “Rotor Dynamics”, New Age International Publication, New Delhi, India, Third Ed., 2018
2	Chen, Wen Jeng, and Edgar J. Gunter. "Dynamics of rotor-bearing systems." Victoria, Canada: Trafford Publishing , 2010.
3	Krämer E., “Dynamics of Rotors and Foundations,” Springer-Verlag, New York, 2013.
4	Rao S.S. “The finite element method in Engineering,” Elseiver, 2005.
5	Raj S. and Littleson J. E., “Rotor and Structural Dynamics of Turbomachinery – A Practical Guide for Engineers and Scientist”, Springer International Publishing, Heidelberg, Germany, 2018.

METM107	:	COMPUTATIONAL AND EXPERIMENTAL LABORATORY – I	L	T	P	Credits
			0	0	6	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Learn overview of data analysis and programming and machine learning softwares
CO2	Solve linear and non-linear algebraic equations using numerical techniques and computer programming
CO3	Solve initial value problems and boundary value problems using computer programming
CO4	Apply the concept of laminar and turbulent flow measurements
CO5	Analyse and evaluate the observations and deduce conclusions in flow systems
CO6	Develop team effort and coordination through group practical performance

Software based practices

1. Introduction to MATLAB
2. Introduction to Mathematica
3. Introduction to functions of Microsoft Excel
4. Introduction to C and C++ programming
5. Introduction to Fortran programming
6. Introduction to Labview Coding
7. Introduction to SCADA Coding

Coding

1. Introduction to compiler, scripts, loops, logical statements
2. Solving ODE using Rung-Kutta method of 2nd order: Heun's method, Mid-point method, and Ralston's method
3. Solving ODE using Rung-Kutta method of 3rd order, and 4th order
4. FDM code to solve PDE: elliptic equation
5. FDM code to solve PDE: parabolic equation
6. FDM code to solve PDE: hyperbolic equation
7. Lab view programming of simultaneous mass flow controller operation
8. Lab view programming for simultaneous triggering
9. Demonstration of SCADA panel for controlling and monitoring thermo-fluid parameters for combustor test-rig.
10. Demonstration of SCADA panel for controlling and monitoring thermo-fluid parameters for heat-exchanger test-rig.

2. Laboratory Experiments

1. Estimation of velocity distribution for flow through rectangular and circular passage in laminar and turbulent regime
2. Estimation of momentum and energy correction factor for flow through rectangular and circular passage
3. Identification of flow regimes in two-phase flow
4. Estimation of pressure drop in single phase flow with or without obstruction
5. Estimation of two-phase pressure drop for flow through circular passage.
6. Estimation of drag on bluff and streamlined body using wind tunnel
7. Estimation of impact of jet on planer and curved surfaces
8. Calibration of reference velocity and longitudinal static pressure variation in the test section of an open-type subsonic wind tunnel.
9. Measurement of pressure distribution over an airfoil surface using subsonic type wind tunnel.
10. Use of Method of Characteristics for design of nozzles

METM102	:	DESIGN OF TURBOMACHINES	L	T	P	Credits
			3	1	0	04

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the working principles of turbomachines and apply it to various types of turbomachines
CO2	Design compressors and gas turbines.
CO3	Determine the off-design behavior of axial and Radial turbines and compressors
CO4	Design pumps and hydro turbines
CO5	Establish performance characteristics curves of thermal and hydro turbomachines
CO6	Assess & analyze the performance outcomes of thermal and hydro turbomachines.

2. Syllabus:

Design of Centrifugal Compressors	**(06 Hours)**
Components of centrifugal compressor, velocity diagrams, slip factor, energy transfer, power input factor, mollier chart, stage pressure rise and loading coefficient, degree or reaction, pre-whirl and inlet guide vanes, kinematic parameters, Centrifugal compressor — Inlet section, Impeller passages, operational range, velocity variation, Losses.	
Design of Axial Flow Compressors	**(15 Hours)**
Description of axial flow compressor, Mollier chart, velocity diagrams, Stage characteristics, Blading efficiency, Design parameters, Blade loading, reaction ratio, Lift coefficient and solidity, Three dimensional flow considerations, Radial equilibrium design approach, Actuator disc theory approach, Design procedure and calculations, free vortex blade, forced vortex or solid rotation blades, constant reaction blade, multistage compression, secondary flow (passage vortex, trailing vortex, corner vortex, horseshoe vortex, leakage vortex, scraping vortex) and loss assessment, rotating stall, surge, chocking, operating range.	
Design of Turbine Flow Passages	**(06 Hours)**
Introduction, Isentropic Velocity ratio, Energy distribution in turbines, different efficiencies (nozzle efficiency, carryover efficiency, blade passage efficiency, vane efficiency, stage efficiency), reheat factor, losses in turbine, h – s diagrams of turbines.	
Design of Impulse Turbine Flow Passages	**(08 Hours)**
Velocity triangles, work and energy relationship, stage efficiency, Blade pitch and width, Blade height, Blade entrance and exit angles, Geometry of impulse blade profiles, Losses in impulse blade passages, Design procedure for single stage and multistage impulse turbines, diagram efficiency of a two stage turbine, Pressure compounding (Rateau Turbine), Velocity	

compounding (Curtis Turbine), Pressure and Velocity compounding. Work done and efficiency of a Pelton wheel turbine, heads and efficiencies of Pelton wheel turbine.	
Design of Reaction Turbine Flow Passages	**(06 Hours)**
Reaction blade profiles, Blade angles, Blade width and height, Losses in reaction blade passages, Degree of reaction, design procedure for impulse reaction turbines, Calculations for axial thrust, Turbines for optimum capacity.	
Hydraulic Design of Centrifugal Pumps	**(04 Hours)**
Fundamental Equation of centrifugal pump, work done and manometric efficiency, pressure rise in pump impeller, overall, mechanical, volumetric and manometric efficiency, ideal, virtual and Manometric heads, Net Positive Suction Head, one dimensional theory, Selection of speed - determination of impeller inlet and outlet dimensions	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Yahya S. M., “Turbines, Compressors and Fans” Tata McGraw Hill, New Delhi, India, 2010
2	Saravanamuttoo, H. I., Rogers, G. F. C., & Cohen, H. “Gas turbine theory” Pearson education, 2001
3	Ganesan V.., “Gas Turbines”, Tata McGraw Hill Education (India) Private Limited, 2017.
4	Venkanna B. K. , “Fundamentals of Turbomachinery”, PHI, India, 2010
5	Sawhney G. S., “Thermal and Hydraulic Machines”, Prentice Hall India Learning Pvt. Ltd., India, 2011.

METM104	:	COMBUSTION FOR PROPULSION SYSTEMS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Analyse the combustion system using principles of thermodynamics.
CO2	Model combustion kinetics and chemical explosion mechanisms
CO3	Explain basic concepts about various types of flames; modelling and application to energy systems.
CO4	Analyse combustion characteristics and how these can be measured.
CO5	Illustrate different type of pollutants generated by combustion, their effects on health and on the environment and various methods to control it.
CO6	Describe different combustion mechanisms and how these can be efficiently used in engineering applications.

2. Syllabus:

Introduction	**(04 Hours)**
Introduction to combustion, Applications of combustion, Types of fuel and oxidizers, Characterization of fuel, Various combustion mode, Scope of combustion, Fundamental laws of transport phenomena, Conservations Equations.	
Thermodynamics of Combustion	**(08 Hours)**
Mixture composition, energy and entropy properties of gaseous mixtures, Thermodynamic properties of reacting mixtures, Laws of thermodynamics, Stoichiometry, Thermochemistry, adiabatic temperature, chemical equilibrium. Conditions of chemical equilibrium, equilibrium constant, challenges in chemical equilibrium.	
Combustion Kinetics	**(08 Hours)**
Basic Reaction Kinetics, Elementary reactions, Chain reactions, Multistep reactions, simplification of reaction mechanism, Global kinetics reaction rate formula, approximations for construction of global reaction rate, global rates of hydrocarbon fuels.	
Chemical Mechanisms	**(03 Hours)**
Explosive and oxidative characteristics of fuels, Criteria for explosion, Explosion limits and oxidation of hydrogen, Carbon monoxide and hydrocarbons.	
Premixed Flames	**(06 Hours)**
Laminar premixed flame, laminar flame structure, Stability limits of laminar flames, Laminar flame speed, Flame speed measurements, Flame stabilizations, Ignition and	

quenching, Turbulent flames, turbulent flame speed, external aided ignition (spherical propagation, plane propagation), auto ignition, flammability limits.	
Diffusion Flames	**(06 Hours)**
Laminar Diffusion flames, turbulent diffusion flames, Schvab-Zel'dovich formulation, Burke-Schumann problem, Gaseous Jet diffusion flame, Droplet Combustion, Liquid fuel combustion, Atomization, Spray and Solid fuel combustion.	
Combustion and Environment	**(04 Hours)**
Atmosphere, Chemical Emission from combustion, Quantification of emission, mechanisms of pollutant formation during combustion, pollutants reduction in conventional combustors, pollutants reduction by control of flame temperature, dry low-oxides of nitrogen combustors, lean premix per vaporize combustion, rich-burn quick-quench lean burn combustor, catalytic combustion, correlations and modelling of oxides of nitrogen and carbon monoxide emission.	
Combustion Process in Propulsion Systems	**(06 Hours)**
Principal ideas of combustion in gas turbine, solid propellant rockets: Erosive burning, and liquid propellant rockets.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Kuo K.K., "Principles of Combustion", John Wiley, USA, 2005.
2	Turns S.R., "An Introduction to Combustion", New York: McGraw-Hill, NY, USA, 2017.
3	Law C.K., "Combustion Physics", Cambridge University Press, Cambridge, United Kingdom, 2010.
4	Mishra D.P., "Fundamentals of Combustion", Prentice Hall of India, New Delhi, INDIA, 2010.
5	Mukunda H. S., "Understanding Combustion", Universities Press, Hyderabad, Telangana, 2009.

METM130	**:**	**MICRO-HYDRO POWER PLANT**	**L**	**T**	**P**	**Credits**
			3	**0**	**0**	**03**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the concepts of hydro-electric power plants and classify different hydro-electric and micro-hydro-electric power plant
CO2	Analyze flow prediction methods and evaluate flow transfer systems required based on site conditions
CO3	Identify different types of turbines and analyze the performance characteristics of various turbines
CO4	Explain the working of different components of governing systems, and select the appropriate governing and drive for suitable application
CO5	Compare the working of different electrical power sources
CO6	Prepare maintenance schedule of components of micro hydro plant and carry out fault diagnosis

2. Syllabus:

Introduction	**(06 Hours)**
Classification of Hydro-Electric Power Plant, micro hydro power plant overview and components.	
Hydrology, Site Survey, and Civil Works	**(10 Hours)**
Introduction, flow prediction, head measurements, site measurements of flow, civil works, system layout, Weir, spillways, channel, penstocks.	
Turbines	**(12 Hours)**
Overview of Turbines, Construction, and operating principles, Types: impulse, Pelton, Turgo, Crossflow, Reaction, Francis, Propeller, Kaplan, and reverse pump: selection of turbine.	
Governing and Drive System	**(06 Hours)**
Purpose of governing, approaches to the governing, direct couple drives: components.	
Electrical Power	**(06 Hours)**
Basic electricity, choosing the supply, generators, synchronization.	
Operation and Maintenance	**(05 Hours)**
Maintenance of components of micro hydro plant, fault diagnosis.	

(Total Lecture Hours: 45)

3. <u>Books Recommended:</u>

1	P. Fraenkel, O. Parish, V. Bolkalders, A. "Harvey, Micro-hydro Power: A guide for development workers", ITDG Publishing,1991.
2	L. Kindberg, "Micro-Hydro Power: A Beginners Guide to Design and Installation, National Center for Appropriate Technology", 2014.
3	A. Harvey, "Micro-Hydro Design Manual: A Guide to Small-Scale Water Power Schemes", Intermediate Technology Publications, 1993.
4	V. Schnitzer, "Micro hydro Power scout guide" Hydro Power GTZ, 2009.
5	J.M. Chapallaz, P. Eichenberger, G. Fischer. "Manual on pumps used as turbines", Vieweg, 1992.

METM132	:	THEORY AND DESIGN OF CRYOGENIC SYSTEMS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Select suitable cryogen and material for developing cryogenic systems for different applications.
CO2	Design and analyze of gas liquefaction systems and cryogenic refrigeration systems, including cryocoolers.
CO3	Select proper cryogenic insulating material and designing of cryogenic insulation.
CO4	Analyse gas purification and separation system using cryogenics.
CO5	Select and design storage, handling, and transfer systems for cryogens.
CO6	Design vacuum system for the cryogenic application.

2. Syllabus:

Introduction and Applications	**(02 Hours)**
Cryogenics Fluids	**(02 Hours)**
Properties of Air, Oxygen, Nitrogen, Hydrogen, Helium and its isotopes	
Properties and Selection of Materials	**(03 Hours)**
Study of material properties & their selection for the cryogenic application.	
Gas Liquefaction and Refrigeration Systems	**(10 Hours)**
Basics of Refrigeration, Ideal system, Linde Hampson system, Precooled Linde Hampson system, Linde dual pressure system, Claude system, Heylandt system, Kapitza system, Collins cycle.	
Cryogenic Insulation	**(07 Hours)**
Vacuum insulation, Multilayer insulation (MLI), Methods of measuring the effective thermal conductivity of MLI, Liquid & vapor shield, Evacuated porous insulation, Gas-filled powders, and fibrous materials, Solid foams, Vacuum technology.	
Cryocoolers	**(06 Hours)**
Ideal Stirling cycle, Design parameters (Schmidt’s Analysis), GM cryocooler, Pulse Tube cryocooler, Phasor Analysis.	
Cryogenic Instrumentation	**(04 Hours)**
Peculiarities of cryogenic strain measurement, Pressure, Flow, Density, Temperature, and liquid level measurement for cryogenic application.	

Storage & Handling Systems	(04 Hours)
Dewar vessel design, Piping, Support systems, Vessel safety devices and storage systems, Industrial storage systems.	
Transfer Systems	**(04 Hours)**
Transfer from storage, Uninsulated transfer lines, Insulated lines, and Transfer system components.	
Gas Separation	**(03 Hours)**
Principles of gas separation, Ideal system	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Haselden, C., Cryogenic Fundamentals, Academic Press, 2001.
2	Barron R., Cryogenic Systems, Plenum Press, 2001.
3	Walker G., Cryocoolers, Springer, 2014.
4	Mikulin, Y., Theory and Design of Cryogenic systems, MIR Publication, 2002.
5	Barron, R. F., Cryogenics Systems, Oxford Press., USA, 2002

METM134	:	CASCADE AERODYNAMICS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the concept of cascade and its terminology
CO2	Explain the difference between low speed and high speed cascade testing
CO3	Illustrate 3-D flows and non-rectilinear cascades
CO4	Explore effects of design parameters on cascade
CO5	Apply the knowledge of different flow theories and their behavior in cascade
CO6	Elucidate different flow and their behavior in cascade

2. Syllabus:

Introduction of Cascade Model	**(08 hours)**
Meridional & cascade planes, Cascade notation & definitions, Equations of motion & efficiency, Cascade force analysis, Brief about Tandem cascade.	
Low Speed Cascade Testing	**(06 hours)**
Introduction, Axial velocity variation through cascades, Influence of Reynolds number, Effect of free stream turbulence, Details about design feature of low speed cascade tunnel.	
3-D Flows & Non- Rectilinear Cascades	**(07 hours)**
Axial velocity ratio effect, Aspect ratio effect, Applications of cascade to mixed and radial flow, Secondary flow and losses, End-wall boundary layers.	
High Speed Cascade Testing	**(09 hours)**
Subsonic and transonic wind tunnels, Testing of high speed compressor and turbine cascades, Instrumentation and observation techniques.	
Design Application of Cascade Information	**(09 hours)**
The effect of geometric parameters, The effect of aerodynamic parameters, Interactive parameters	
Different Flow and Their Behavior in Cascade	**(06 hours)**
Potential flow, compressible flow, viscous flow, stalled and unsteady flow	

(Total Lecture Hours: 45)

3. Books Recommended:

1	William R. Hawthorne "Aerodynamics of turbines and compressors", Princeton university press, New Jersey, 2017
2	Saravanamuttoo, H. I., Rogers, G. F. C., & Cohen, H. "Gas turbine theory" Pearson education, 2001.
3	Dixon S. L., C.A. Hall "Fluid Mechanics and Thermodynamics of Turbomachinery" Elsevier Inc., Netherlands 2014
4	Yahya S. M. "Turbines, compressors and fans" Tata McGraw hill education private limited, USA, 2011.
5	Boyce, M. P., Gas turbine engineering handbook. Elsevier, 2011.

METM136	:	CONDITION MONITORING AND FAULT DIAGNOSIS OF ROTATING MACHINERY	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe basic terminologies used in condition monitoring of rotating machinery.
CO2	Examine vibration analysis of complex rotating systems with non-linear effects included.
CO3	Identify and analyse rotating machinery faults using different methods.
CO4	Illustrate the utility of instrumentation and terminology used in signal analysis for fault detection in rotating machinery.
CO5	Analyse various plots used in condition monitoring of rotors predict rotor faults.
CO6	Analyse faults in rotating machinery

2. Syllabus:

Introduction to Condition Monitoring	**(06 Hours)**
Introduction to condition monitoring, Maintenance approach, Basics of machinery vibration, Conventions and characteristics - amplitude, frequency and phase.	
Vibration Analysis of Complex Rotating Systems	**(12 Hours)**
Asymmetric rotors, Axial vibrations, Torsional vibration - Holzer`s method, Transfer Matrix method, Geared and Branched systems, Effect of isotropic and anisotropic supports, Alford force, Whirling of rotor, Campbell diagram, Overhung rotors, Morton effect, Temperature effect on vibration.	
Rotating Machinery Faults and Detection	**(12 Hours)**
Rotating machinery faults and its detection - Unbalance, Misalignment, Bent rotors, Bearing defects, Oil Whirl, Oil whip, Looseness, Electric motor defect, Rotor stator rub etc., frequency range of faults, Non-destructive testing, Acoustic emission technique and applications, Introduction to Active magnetic bearing.	
Instrumentation and Signal Analysis	**(09 Hours)**
Instrumentation and Fault Detection Transducers - Displacement, Velocity and Acceleration, Computer aided data acquisition, Oscilloscope, Vibration Exciter systems, Signal Analysis, Basics of FFT, Trend plot, Time domain plot, Frequency domain plot, Spectrum plot, Waterfall plot, RMS, Peak and Peak-peak value, Case studies - Spectrum interpretation charts, Correlation analysis, cepstrum analysis, time averaging and trend analysis, wavelet analysis, model-based information extraction, signal conditioning, data acquisition	

Condition Monitoring of Rotors	(06 Hours)
Diagnostic Data and Tools (Shaft Relative Vibration Measurement, Seismic Vibration Measurement of Structures, Shaft Absolute Vibration Measurement, Bearing Metal Temperature Measurement), Load Variations, Pressure Variations, Diagnostic Data (Bode Plot, Polar Plot, Shaft Centreline Plot, Spectrum Plot), Angular Velocity Measurement methods in shaft, closing of rotor-stator clearances, cylinder distortion/misalignment, ingress of a cooling media (cool steam / water induction), lube oil influence on increased rotor vibration, faults detectable from the stator force wave, torsional oscillation monitoring (IAS), shock pulse monitoring.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Tiwari R., Rotor Systems: “Analysis and identification,” CRC Press, Florida, 2017.
2	Michael I. F., John E. T. Penny, Seamus D. Garvey, Arthur W. Lees, “Dynamics of Rotating machines”, Cambridge University Press, England, 2010.
3	Davies A., “Handbook of Condition Monitoring: Techniques and Methodology”, Springer Science & Business Media, Germany ,2012.
4	Rao J. S. “Rotor Dynamics”, New Age International Publication, New Delhi, India, Third Ed., 2018.
5	Peter T., Li Ran and Christopher Crabtree, “Condition Monitoring of Rotating Electrical Machines”, The Institution of Engineering and Technology, 3 rd Edition, India, 2020.

METM138	:	TURBULENT COMBUSTION	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Formulate turbulence in reacting and non-reacting flows
CO2	Explain various scales in turbulent premixed
CO3	Model premixed turbulent flames
CO4	Describe measurements in premixed turbulent flame
CO5	Model turbulent non-premixed flames
CO6	Demonstrate measurements in premixed turbulent flame

2. Syllabus:

Introduction	**(08 Hours)**
Introduction of various governing equations in the combustion, concepts of laminar premixed and non-premixed flames, concepts of turbulent-flows — Characteristics, Statistical understanding of turbulence, conventional averaging methods, turbulence model, probability density function, turbulent scales, LES and DNS simulation	
Turbulent Premixed Flames	**(10 Hours)**
Introduction and basic concepts of turbulent premixed flames, Correlation — Damkholer Analysis, Schelkin's Analysis, Karlovitz, Denniston and Wells's Analysis, Summerfield's Analysis, Kovasznay's Characteristic Time Approach, Limitations of the Preceding Approaches. Characteristic Scale of Wrinkles in Turbulent Premixed Flames — Structure of Wrinkled Laminar Flames, Measurements of Scales of Unburned and Burned Gas Lumps, Length Scale of Wrinkles	
Premixed Turbulent Flame Modeling and Measurements	**(09 Hours)**
Development of Borghi Diagram for Premixed Turbulent Flames — Physical Interpretation of Various Regimes in Borghi's Diagram, Turbulent Combustion Modeling Approaches, G-Equation, Scales in Turbulent Combustion, Closure of Chemical Reaction Source Term, Probability Density Function Approach to Turbulent Combustion.	
Non-Premixed Turbulent Flames	**(10 Hours)**
Introduction- non-premixed flames, non-premixed turbulent flame limitations. Turbulent Damkohler number, Turbulent Reynolds Number, Scales in Non-premixed Turbulent Flames, Turbulent Non-premixed Combustion Regime Diagram, Turbulent Non-premixed Target Flames — Simple Jet Flames, Piloted Jet Flames, Turbulence-Chemistry Interaction-Infinite Chemistry assumptions, unity Lewis number and non-unity Lewis number.	

Non-Premixed Turbulent Flame Modeling and Measurements	(06 Hours)
Probability Density Approach for Turbulent Non-premixed Combustion— Physical Models, Turbulent Transport in Velocity-Composition Pdf Methods, Molecular Transport and Scalar Mixing Models, Flamelet Models— Laminar Flamelet Assumption, Unsteady Flamelet Modeling, Flamelet Models and PDF. Interactions of Flame and Vortices— Flame Rolled Up, Experimental Setups for Flame/Vortex Interaction Studies, Generation and Dissipation of Vorticity Effects, Non-premixed Flame–Vortex Interaction, Flame Instability in Non-premixed Turbulent Flames.	
Partially Premixed Flames or Edge Flames	**(02 Hours)**
Formation of Edge Flames, Triple Flame Stabilization of Lifted Diffusion Flame, Analysis of Edge Flames	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Turns S.R., “An introduction to combustion”, New York: McGraw-Hill, USA, 2017.
2	Kuo K.K., “Principles of Combustion,” John Wiley, USA, 2005.
3	Kuo, Kenneth Kuan-yun, and Ragini Acharya. “Fundamentals of turbulent and multiphase combustion.” John Wiley, USA, 2012.
4	Peters, N. "Turbulent combustion. Cambridge, UK: Cambridge University Press.", UK, 2000.
5	Swaminathan, Nedunchezhian, Bai X-S., Haugen N. E. L., Christer Fureby, and Geert Brethouwer, eds. “Advanced Turbulent Combustion Physics and Applications”. Cambridge University Press, UK, 2022.

METM140	:	WIND ENERGY CONVERSION SYSTEMS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe the importance of wind energy sector
CO2	Analyse aerodynamic loads on wind turbines
CO3	Evaluate the performance parameters of wind turbines
CO4	Design the components of wind energy systems.
CO5	Analyse horizontal axis wind turbine systems
CO6	Examine the economics and feasibility of wind energy systems.

2. Syllabus:

Introduction	**(07 Hours)**
The nature of wind, Geographical variation in wind resources, Long term wind speed variations, Turbulence, Extreme wind speed, Turbulence in wakes and Wind farms	
Aerodynamics of Horizontal Axis Wind Turbine	**(09 hours)**
Introduction, Actuator disc concept, Rotor disc theory, Vortex cylinder model of the actuator disc, Rotor blade theory, Breakdown of momentum theory, blade geometry, effect of discrete number of blades, calculated results for an actual turbine	
Wind Turbine Performance	**(06 hours)**
The performance curves, constant rotational speed Operation, Comparison of measured with theoretical performance, variable speed operation, Estimation of energy capture, Wind turbine performance measurement, Aerodynamic Performance measurement	
Conceptual Design of Horizontal Axis Wind Turbine	**(07 hours)**
Introduction, Rotor diameter, Machine rating, Rotational speed, number of blades, Power control, Braking system, Fixed Space, Two Speed or variable speed operation, Type of generator	
Component Design	**(06 hours)**
Blades, Pitch bearings, Rotor Hub, Gearbox, Generator, Mechanical Brake, yaw drive, Tower, Foundations, Wind Turbine Control	
Wind Energy System Economics and Feasibility	**(05 hours)**
Engineering Economics Basics, Wind Turbine Cost Analysis, Wind Farm Feasibility Studies, Environmental and Wildlife Impact, Noise Issues	
Special Topics	**(05 hours)**

Vertical Axis Turbine, Floating Windmill, Diffuser augmented wind turbines, Airborne wind turbine, Recent developments in wind energy conversion

(Total Lecture Hours: 45)

3. <u>Books Recommended:</u>

1	Ahmed S., “Wind Energy: Theory and Practice”, PHI learning, India, 2011.
2	Maxwell J. F., McGowan J. G., and Rogers A. L., “Wind Energy Explained – Theory, Design, and Applications,” John Wiley & Sons, USA,2010
3	Hansen M., “Aerodynamics of Wind Turbines,” Routledge, UK, 2015.
4	Heier S., “Grid Integration of Wind Energy Conversion Systems,” Wiley, USA, 2014.
5	Nelson V., “Innovative wind turbines- an Illustrated guide book, CRC press Taylor & Francis, US, 2020

METM142	:	MULTIPHASE FLOWS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Identify multiphase flows regimes
CO2	Assess diverse approaches to solving critical problems in multiphase reactor
CO3	Formulate computational models for multiphase flow.
CO4	Establish the residence time distribution and measurement techniques for various systems
CO5	Examine how to apply the concepts of multiphase fluid flow
CO6	Apply two-Fluid Models in multiphase flow with interphase exchanges

2. Syllabus:

Fundamentals of Multi Phase Flow	**(12 Hours)**
Introduction to multiphase flow, types and applications, Common terminologies, flow patterns and flow pattern maps. Governing equations for homogeneous, separated and drift-flux models; lockhart and Martinelli procedure, gas-liquid flow in pipes, flow regimes in vertical, horizontal and inclined pipes, pressure drop and void fraction modelling for specific flow regimes. Dynamics of particles submerged in fluids, flow through packed bed, fluidization, calculation of pressure drop in fixed bed, determination of minimum fluidization velocity, expanded bed, dilute phase, moving solid fluidization, elutriation in fluidized bed, semi-fluidization, pulsating columns, oscillating fluidized bed. Gas-liquid particle process, gas liquid particle operation, flow of gas-bubble formation, bubble growth gas holdup, gas mixing liquid holdup, liquid mixing, flow of liquid mixing, gas liquid mass transfer	
Types of Multiphase-Reactors	**(08 Hours)**
Various types of multiphase reactors. e.g. Packed bed, packed bubble column, trickle bed reactor, three phase fluidized bed reactor, slurry bubble column, stirred tank reactor. Characteristics of above mentioned reactors such as; fluid flow phenomena and flow regimes, flow charts/ correlations, pressure drop, liquid hold up etc.	
Computational Models in Multiphase Flow	**(04 Hours)**
Overview of numerical approach, Direct Numerical Simulations of Gas-Liquid Flow, Lattice Boltzmann Method, Immersed Boundary Method, PDF models for particle transport mixing and collisions in Turbulent flow, Euler-Lagrange Methods, Two-Fluid Model in multiphase flow with interphase exchanges, Uncertainty Quantification.	

RTD in Multiphase Flow Systems	(09 Hours)
Residence time distribution of fluid in vessel, E, F & C Curve, Mean and variance, the Dirac delta function, residence time, linear and non-linear processes, models for non ideal flow, dispersion model, N tanks in series model, model for small deviations from plug flow and long tails, conversion in a reactor using RTD data, diagnosing ills of operating multiphase reactors, models for multiphase reactors. Two parameter model; PD model; three parameter models; PE Model	
Measurement Techniques in Multiphase Flow	**(06 Hours)**
Conventional and novel measurement techniques for multiphase systems (Laser Doppler anemometry, Particle Image Velocimetry)	
Applications of Multiphase Flow	**(06 Hours)**
One Dimensional Three Phase Flow example – Pump model: Variables defining the pump behaviour, theoretical basis, Suter Diagram, Computational Procedure, Centrifugal Pump Drive Model, Extension of the Theory to Multiphase Flow. Detonation waves due to chemical reactions: Introduction, Single phase theory (Laprace Continuum Sound Waves, Rankine Hugoniot Discontinuum Shock waves, Landau and Lifshitz Analytical Solution for detonation in perfect gas, numerical solution for detonation in closed pipe), multiphase flow (continuum sound wave, discontinuous shock waves, comparison with Yeun and The of Anous Formalism, numerical solution)	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Carey V. "Liquid-Vapor Phase-Change Phenomena," Taylor and Francis:, USA, 2007.
2	Fan, L. S. and Zhu, C., "Principles of Gas-solid Flows," Cambridge University Press, England,1999
3	Westerterp K.R., van Swaaij W.P.M., and Beenackers "Chemical Reactor Design and Operation," Wiley, USA, 1991.
4	Efstathios E. Michaelides, Clayton T. Crowe, John D. Schwarzkopf, "Multiphase Flow Handbook", CRC Press, Florida,2017
5	Kolev N. I., "Multiphase Flow Dynamics 1 – Fundamentals", Springer Publications, UK, 2015.

METM144	:	FLOW AND FLAME DIAGNOSTICS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe the need for diagnostics experiments in fluid flow and reacting flow
CO2	Differentiate the intrusive and non-intrusive techniques
CO3	Explain the concepts and methods of various diagnostics techniques in fluid flow and reacting flow
CO4	Describe the equipment and its arrangement to carry out diagnostics experiments in non-reacting and reacting systems.
CO5	Demonstrate different analysis techniques commonly used in diagnostics experimental work
CO6	Interpret diagnostics data in fluid mechanics and combustion

2. Syllabus:

Introduction to Optical Flow Diagnostics	**(09 Hours)**
Overview of probe measurement techniques, limitation of the probe measurement techniques, Importance of diagnostics, Intrusive vs. Non-Intrusive Measurements, Point vs. Planar Measurements, Spatial vs. Temporal Resolution, Time vs. Ensemble Averaging.	
Equipments For Diagnostics	**(12 Hours)**
Lasers, Camera, Synchronization, Seeding, Light sheet optics, Image Processing	
Techniques	**(12 Hours)**
Heat Release Rate — Chemiluminescence Imaging (CH, OH, C2, CO2), PLIF (CH, OH, HCHO, H), Temperature —2 Line PLIF, IR Camera, Thermographic Phosphors, Mixture Fraction, Acetone PLIF, Rayleigh Scattering, LDV, Velocity — 2D-2C PIV, 2D-3C PIV (Stereo), 3D-3C PIV (Tomographic).	
Advanced Topics	**(12 Hours)**
Soot — LII, Droplet & Spray Measurements — ILIDS-(Droplet Sizing), PDPA (Velocity & Size), Density Gradient —Schlieren, Rhodhamine PLIF, Shadowgraphy.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Van de Hulst H. C. “Light Scattering by Small Particles”, Dover, New York, USA, 2012
2	Tropea, C., Yarin, A. L., & Foss, J. F. (Eds.). “Springer handbook of experimental fluid mechanics”, Berlin: Springer, 2007.
3	Eckbreth C. “Laser Diagnostics for Combustion Temperature and Species”, Gordon & Breach, USA,1996.
4	Kohse-Höinghaus K., Barlow R. S., M. Aldén and J. Wolfrum, “Combustion at the focus: laser diagnostics and control”, Comb Inst, 2005.
5	Raffel M., Willert C. E., Kompenhaus J. “Particle Image Velocimetry: A Practical Guide,” Springer-Verlag, USA, 1998.

METM146	:	THERMOACOUSTIC INSTABILITIES	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe various instability observed in combustion systems
CO2	Derive governing equations in thermo-acoustic problem
CO3	Explain the origin of thermo-acoustic instabilities in a combustor
CO4	Evaluate the natural frequency of a combustor
CO5	Examine disturbance and flame response to harmonic excitation
CO6	Assess active and passive control of combustion instability

2. Syllabus:

Introduction to Acoustics and Combustion Driven Oscillations	**(12 Hours)**
Derivation of the wave equation, Traveling wave solutions, Standing wave solutions, Effect of inhomogeneous media on sound propagation, Multi-dimensional acoustics, Fundamentals of combustion instability, Basic principles, Rayleigh criteria	
Flame Aerodynamics and Flashback	**(04 Hours)**
Boundary Layer Flashback, Core Flow Flashback and Combustion Induced Vortex Breakdown	
Flame Stretch, Edge Flames, and Flame Stabilization Concepts	**(06 Hours)**
Introductory Concepts, Flame Stretch, Edge Flames, Flame Stabilization in Shear Layers, Flame Stabilization by Stagnation Points	
Disturbance Propagation and Generation in Reacting Flows	**(09 Hours)**
Introduction, Decomposition of Disturbances into Fundamental Disturbance Modes, Disturbance Energy, Nonlinear Behavior, Acoustic Wave Propagation Primer, Unsteady Heat Release Effects and Thermoacoustic Instability	
Flame Response to Harmonic Excitation	**(09 Hours)**
Governing Equations: Premixed Flame Dynamics, General characteristics of excited flames, Wrinkle convection and flame relaxation processes, Excitation of wrinkles, Interference processes, Destruction of wrinkles, Non Premixed Flame Dynamics, Global heat release response and Flame Transfer Functions.	
Active and Passive Control of Combustion Instability	**(05 Hours)**
Types and Methods to control combustion instability by active and passive methods.	

(Total Lecture Hours: 45)

3. **Books Recommended:**

1	Kinsler L. E., Frey A. R., A. B. Coppens and J. V. Sanders “Fundamentals of Acoustics”, Wiley, USA, 2000.
2	Lieuwen, Tim C. Unsteady combustor physics”. Cambridge University Press, England 2012.
3	Anderson, William E., and Vigor Yang, eds. “Liquid rocket engine combustion instability”. American Institute of Aeronautics and Astronautics, USA, 1995.
4	Natanzon MS. “Combustion instability.” American Institute of Aeronautics and Astronautics, USA, 2008.
5	Novozhilov, Vasily B., and Boris V. Novozhilov. “Theory of Solid-Propellant Nonsteady Combustion.” John Wiley & Sons, USA, 2020.

METM148	:	MACHINE LEARNING FOR THERMAL SYSTEMS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain different types of machine learning and map problems to different classes of machine learning algorithms
CO2	Describe and apply machine-learning algorithms including decision trees, naïve Bayes, and logistic regression.
CO3	Design and implement advanced neural network architectures, including Multilayer Perceptrons (MLPs), Convolutional Neural Networks (CNNs), and Recurrent Neural Networks (RNNs) (including LSTM and GRU variants), to solve complex real-world problems.
CO4	Utilize Bayesian Regression, Binary Trees, Random Forests, Support Vector Machines (SVM), Naïve Bayes, k-Means, k-Nearest Neighbors (kNN), Gaussian Mixture Models (GMM), and Expectation Maximization (EM) to analyze and optimize mechanical systems
CO5	Evaluate the performance of algorithms and compare different machine learning techniques.
CO6	Apply structured probabilistic models, Monte Carlo methods, autoencoders, and generative adversarial networks (GANs) to analyze and optimize mechanical systems

2. Syllabus:

Mathematical Basics	**(04 Hours)**
Introduction to Machine Learning, Linear Algebra, Probability	
Computational Basics	**(05 Hours)**
Numerical computation and optimization, Introduction to Machine Learning packages	
Linear and Logistic Regression	**(05 Hours)**
Bias/Variance Tradeoff, Regularization, Variants of Gradient Descent, MLE, MAP, Applications.	
Neural Networks	**(14 Hours)**
Multilayer Perceptron, Backpropagation, Applications, Convolutional Neural Networks: CNN Operations, CNN architectures, Training, Transfer Learning, Applications, Recurrent Neural Networks: RNN, LSTM, GRU, Applications	
Classical Techniques	**(09 Hours)**
Bayesian Regression, Binary Trees, Random Forests, SVM, Naïve Bayes, Applications, k-Means, kNN, GMM, Expectation Maximization, Applications.	
Advanced Techniques	**(08 Hours)**

Structured Probabilistic Models, Monte Carlo Methods, Autoencoders, Generative Adversarial Networks

(Total Lecture Hours: 45)

3. Books Recommended:

1	Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning (Adaptive Computation and Machine Learning series), The MIT Press, 2016
2	Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2016
3	Geoff Dougherty, Pattern Recognition and Classification: An Introduction, Springer, 2013
4	Sebastian Raschka, Yuxi (Hayden) Liu, Vahid Mirjalili, Dmytro Dzhulgakov, Machine Learning with PyTorch and Scikit-Learn: Develop machine learning and deep learning models with Python. Packt Publishing Ltd., 2022
5	Manaranjan Pradhan, U Dinesh Kumar, Machine Learning using Python, Wiley, 2020
6	Andreas C. Müller, Sarah Guido, Introduction to Machine Learning with Python: A Guide for Data Scientists, 2016

METM170	:	COMPUTATIONAL FLUID DYNAMICS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Develop mathematical model for fluid flow through turbomachine passage
CO2	Discretize the fundamental equations of flow and other transport processes
CO3	Apply finite volume method for numerical modeling of flow
CO4	Solve flow problems using semi-explicit and semi-implicit algorithms.
CO5	Generate mesh for flow domain in complex turbomachinery geometry
CO6	Solve Navier-Stokes equations for flow through complex turbomachine passages

2. Syllabus:

Governing Equations and Discretization	**(08 Hours)**
Navier-Stokes equations in Integral and differential form for incompressible and compressible flow through turbomachine passage, Energy Equation, Initial and Boundary Conditions, Finite Difference discretization, Errors, Consistency and Von–Neumann Stability Analysis	
Finite Volume Method for Fluid Flow Modeling	**(09 hours)**
Discretization of Unsteady, Diffusion, Advection and Source Terms, Advection Schemes: Central Difference Scheme, First Order Upwind Scheme, Second Order Upwind Scheme, QUICK scheme and Other Higher Order Schemes, Finite Volume Solution of Unsteady Advection, Diffusion Problems with Source Term	
Solution of Navier-Stokes Equations for Viscous Incompressible Flows	**(16 Hours)**
Stream function–vorticity formulation for Two Dimensional Incompressible Viscous Flow, Collocated and Staggered Grid, Solution of Unsteady Navier-Stokes Equations using Semi explicit method for Collocated and Staggered grid, Momentum Interpolation, SIMPLE Algorithm, Formulation for Coupled Flow and Heat Transfer or Other Scalar Transport	
Computational Methods for Complex Domain	**(12 Hours)**
Grid generation in complex geometry: O-type, C-type and H-Type grids around airfoil blades, Algebraic grid generation, Elliptic, hyperbolic and parabolic grid generation, Finite volume discretization of Navier-Stokes equations in complex domain, Grid-free vortex methods, decomposition of flux vector, applications in turbine cascade	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Versteag H. K., and Malalsekara W., An Introduction to Computational Fluid Dynamics, Pearson, UK, 2008.
2	Chung T. J., Computational Fluid Dynamics, Cambridge University Press, England, 2010.
3	Anderson D. A., Tannehill J. C., Pletcher R. H., “Computational Fluid Mechanics and Heat Transfer”, CRC Press, Florida, 2012
4	Murlidhar K. and Sunderarajan T. “Computational Fluid Flow and Heat Transfer”, Narosa Publisher, New Delhi, India 2013.
5	Anderson J. D., “Computational Fluid Dynamics”, McGraw Hill, NY, USA, 2017.

METM172	**:**	**HYDROGEN ENERGY APPLICATIONS TO PROPULSION AND FUTURE MODES OF TRANSPORT**	**L**	**T**	**P**	**Credits**
			3	**0**	**0**	**03**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Asses and demonstrate the hydrogen production technologies, storage methods and strategies for transition to hydrogen economy
CO2	Analyze the concepts and characteristics of various types of fuel cell
CO3	Explain and demonstrate the working of fuel cells
CO4	Evaluate the economic and environment aspects fuel cells with analysis
CO5	Examine the use of hydrogen fuel in various application of transportation
CO6	Explain hydrogen applications to the propulsion

2. Syllabus:

Introduction	**(09 Hours)**
Hydrogen as a source of energy, physical and chemical properties, salient characteristics, relevant issues and concerns	
Hydrogen Storage	**(12 Hours)**
Production of hydrogen, steam reforming, water electrolysis, gasification and woody biomass conversion, biological hydrogen production, photo dissociation, direct thermal or catalytic splitting of water, hydrogen storage options, compressed gas, liquid hydrogen, hydride, chemical storage, safety and management of hydrogen, applications of hydrogen	
Fuel Cells Types Application and Economics	**(12 Hours)**
Brief history, principle, working, thermodynamics and kinetics of fuel cell process, types of fuel cells; AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerits, performance evaluation of fuel cell, comparison of battery Vs fuel cell. Fuel cell usage for domestic power systems, large scale power generation, automobile, space applications, cost expectation and life cycle analysis of fuel cells, future trends of fuel cells.	
Hydrogen Application to the Propulsion and Transport	**(12 Hours)**
Cryogenic Fuel Technology and Elements of Automotive Vehicle Propulsion Systems, Hydrogen Engines, Pre-Ignition Problems and Solutions, Fuel Delivery Systems, Power output, current status, cryo-engines types, Indigenous Cryogenic Engine and Stage. MIRAI Fuel Cell Vehicle, Residential Application (ENE-FARM), Distributed Power Generation, Triple Combined Cycle Power Generation, Fuel Cell with Biofuels, Portable Applications.	

(Total Lecture Hours: 45)

3. **Books Recommended:**

1	James L. and Andrew D. "Fuel Cell Systems" John Wiley, New York, USA, 2003.
2	Gou, B., Na, W., & Diong, B. "Fuel cells: modeling, control, and applications", CRC press, 2017.
3	Bent Sorensen (Sorensen), "Hydrogen and Fuel Cells: Emerging Technologies and Applications", Elsevier Academic Press, UK, 2018
4	Srinivasan, Supramaniam. "Fuel cells: from fundamentals to applications", Springer Science & Business media, 2006
5	Kazunari Sasaki, Hai-Wen Li, Akari Hayashi, Junichiro Yamabe, Teppei Ogura, Stephen M. Lyth, "Hydrogen Energy Engineering – A Japanese Perspective", Springer Publishers, Heidelberg, Germany 2016

METM174	:	DESIGN OF REACTING SYSTEMS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Formulate different types of reacting systems
CO2	Discriminate various type of reacting systems
CO3	Analyse reacting system thermally and chemically
CO4	Design the gas turbine combustion chambers
CO5	Design the rocket engines
CO6	Describe flame holding and ignition systems

2. Syllabus:

Simplified Conservation Equations for Reacting Flows	**(04 Hours)**
Mass conservation, species mass conservation equation, multicomponent diffusion equation, momentum conservation, energy conservation, the concepts of a conserved scalar.	
Thermal and Chemical Analysis of Reacting Systems	**(10 Hours)**
Constant-Pressure, Fixed-mass reactor, Constant-Volume, Fixed-mass reactor, Well-Stirred Reactor, Plug-Flow Reactor, Application to Combustion systems.	
Design of Gas Turbine Combustion Chambers	**(16 Hours)**
Introduction, Combustor Diffuser — Geometry, performance, Design considerations- Faired diffuser, Dump diffuser, Splitter Vanes, Vortex-Controlled diffuser, Hybrid diffuser, Diffuser for tubular and Tub annular Combustors, testing of diffusor. Aerodynamics of Combustor — Reference quantities, Pressure-Loss parameters, Flow in annulus, Flow through liner holes, Jet Trajectories, Jet Mixing, Dilution zone Design, Correlation of pattern Factor Data, Swirler Aerodynamics, Axial Swirlers, Radial Swirlers, Flat vanes versus curved Vanes. Combustor Performance — Combustion Efficiency, Reaction-controlled systems, Mixing-Controlled systems, Evaporation-Controlled systems, Reaction- and Evaporation-Controlled Systems, Flame Stabilization— Definition of Stability Performance, Measurement of Stability Performance, Water Injection Technique. Bluff-Body Flame holders, Mechanism of Flame stabilization. Ignition— Spark ignition- igniter design, life and performance, Other form of ignition. The ignition process and methods of improving ignition performance. Fuel injection system analysis, Combustion noise. Combustor Cooling system analysis, Emission and Alternative fuels	
Design of Rocket Engines	**(15 Hours)**
Introduction of rocket-engines, Engine requirements and preliminary design, Design of thrust chamber— Thrust chamber layout, Thrust chamber cooling, Injector design, Gas-	

generating device, ignition devices, combustion instability. Design of Gas-pressured and turbo prop-propellant feed system, design of rocket engine control, design of propeller tank, design of liquid propellant space engine. Solid rocket motor design and performance

(Total Lecture Hours: 45)

3. Books Recommended:

1	Turns, S.R., "An introduction to combustion," McGraw-Hill, NY, USA, 2017.
2	Ganesan V.., "Gas Turbines", Tata McGraw Hill Education (India) Private Limited, 2017.
3	Lefebvre, Arthur H., and Dilip R. B. "Gas turbine combustion: alternative fuels and emissions." CRC press, Australia, 2010.
4	Huzel, Dieter K. "Modern engineering for design of liquid-propellant rocket engines" American Institute of Aeronautics & Astronautics, USA, 1992.
5	Jim R. "Design of Liquid Propellant Rocket Engines." Lulu Press, Incorporated, North Carolina, United States, 2016.

METM176	:	TURBULENCE AND TURBULENT FLOWS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Evaluate of turbulent flows
CO2	Explain various types of shear flows
CO3	Analyse turbulent flows statistically
CO4	Explain spectral dynamics of turbulence
CO5	Evaluate and interpret experimental measurements
CO6	Choose a turbulence model for computational flow analysis (CFD)

2. Syllabus:

Introduction	**(03 Hours)**
Nature of turbulence, Method of analysis, generation and diffusion of turbulence, Length scales in turbulent flows	
Turbulent Transport of Momentum and Heat	**(12 Hours)**
The Reynolds equations, elements of kinetic theory of gases, Estimates of Reynolds stress, Turbulent heat transfer, Turbulent shear flow near rigid wall. Transport in stationary, homogeneous turbulence, Transport in shear flows, Dispersion of contaminants, Turbulent transport in evolving flows. Dynamics of Turbulence — Kinetic energy of mean flow, Kinetic energy of the turbulence, Vorticity dynamics, The dynamics of temperature fluctuations	
Shear Flows	**(12 Hours)**
Boundary Free Shear Flows —Almost parallel two dimensional flows, Turbulent wakes, The wake of self-propelled body, Turbulent jets and mixing layers, comparative structure of wakes, jets and mixing layers, Thermal plumes. Wall Bounded Shear Flows —The problem of multiple scales, Turbulent flows in pipes and channels, Planetary boundary layers, The effects of a pressure gradient on the flow in surface layers, The downstream development of turbulent boundary layers	
The Statistical Description of Turbulence	**(06 Hours)**
The probability density, Fourier transforms and characteristic functions, joint statistics and statistical independence, Correlation functions and spectra, The central limit theorem.	
Spectral Dynamics	**(06 Hours)**
Velocity and Length scales in laminar and turbulent boundary layers, molecular versus	

turbulent dissipation, Kolmogorov Microscales of Dissipation, One and three dimensional spectra, The energy cascade, The spectrum of turbulence, The effects of production and dissipation, Time spectra, Spectra of passive scalar contaminants.	
Turbulence Simulations and Modelling	**(06 Hours)**
URANS, eddy viscosity models Zero-order models (Algebraic Models), One-Equation Models, Two-Equation Models, appropriate turbulence modelling for turbomachinery flows using a two-equation turbulence model, Large Eddy Simulation, Direct Numerical Simulation	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Tennekes, H. and Lumley, J.L. “A first course on turbulence”, MIT Press, Cambridge, 2018.
2	Pope S.B. "Turbulence" Cambridge University Press, Cambridge, U.K., 2000.
3	Davidson P.A, “Turbulence” Oxford University Press, Oxford, U.K., 2004.
4	Biswas G. and Eswaran, V. "Turbulent flows" Narosa Publishing House New Delhi, India, 2002.
5	Wilcox, D.C. "Turbulence modeling for CFD", DCW Industries, La Canada, CA, 2006.

METM178	:	FUNDAMENTALS OF SOLID PROPELLANT AND MULTI-PHASE COMBUSTION	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe chemistry and synthesis of propellant
CO2	Explain combustion mechanism of solid energetic materials
CO3	Demonstrate optical diagnostics of solid propellant combustion
CO4	Analyse the thermal decomposition of the solid propellant
CO5	Model multiphase combustion
CO6	Describe measurements in multiphase combustion

2. Syllabus:

Propellant Chemistry, Synthesis, and Formulation	**(10 Hours)**
Flash Pyrolysis of Ammonium Perchlorate-Hydroxyl-Terminated-Polybutadiene Mixtures Including Selected Additives, Gas-Phase Chemical Kinetics of [C. H. N. O], Effect of Molecular Structure on Combustion, Effects of Microstructure on Explosive Behavior, Advances in Solid Propellant Formulations, Hazards Associated with Solid Propellants.	
Combustion of Solid Energetic Materials	**(09 Hours)**
Overview of Combustion Mechanisms and Flame Structures for Advanced Solid Propellants, Physico-Chemical Mechanisms of Solid Propellant Combustion, Flame Structure of Solid Propellants, Experimental Studies of Propellant Combustion.	
Optical Diagnostics of Solid-Propellant Flame Structures	**(05 Hours)**
Introduction, Experimental techniques, Laser-Supported Deflagration of RDX and HMX, Effect of Pressure on HMX Flame Structure, Diffusion Flame Studies via Sandwiches, Counter flow Diffusion Flames, Metal Combustion.	
Thermal Decomposition and Combustion	**(09 Hours)**
GAP/AN/Nitrate Ester Propellants, Experimental Methods, flame structures, Correlation of Thermal Decomposition and Burning-Rate Characteristics.	
Multiphase Combustion	**(12 Hours)**
Droplet evaporation and Burning— applications, simple model of Droplet evaporation— Gas phase Analysis, Droplet Life times, Simple Model of Droplet Evaporation— Mass Conservation, Species Conservation, Energy Conservation, Lifetimes, Spray Statistics— Distribution Function, Simplified Spray Combustion Model for Liquid-Fuel Rocket Engines, Classification of Models Developed for Spray Combustion Processes— Simple Correlations, Droplet Ballistic Models, One-Dimensional Models, Stirred-Reactor Models,	

Locally Homogeneous-Flow Models, Two-Phase-Flow (Dispersed-Flow) Models. Locally Homogeneous Flow Models. Two-Phase-Flow (Dispersed-Flow) Models, Droplet Collison, Optical Techniques for Particle Size Measurements, Effect of Droplet Spacing on Spray Combustion

(Total Lecture Hours: 45)

3. Books Recommended:

1	Turns S.R., "An introduction to combustion", New York: McGraw-Hill, USA, 2017.
2	Kuo K.K., "Principles of Combustion," John Wiley, USA, 2005.
3	Kuo, Kenneth Kuan-yun, and Ragini Acharya. "Fundamentals of turbulent and multiphase combustion". John Wiley, USA, 2012.
4	Yang, Vigor, ed. "Solid propellant chemistry combustion and motor interior ballistics "American Institute of Aeronautics & Astronautics, USA, 2000.
5	Huggett, Clayton, Charles E. Bartley, and Mark M. Mills. Solid propellant rockets. Vol. 2373. Princeton University Press, 2015

			L	T	P	Credits
METM108	**:**	**COMPUTATIONAL AND EXPERIMENTAL LABORATORY – II**	**L**	**T**	**P**	**Credits**
			0	**0**	**4**	**02**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the features available in meshing software, turbo-grid, and CFD solver
CO2	Solve thermo-fluid and turbomachines problems using a CFD solver.
CO3	Solve lid-driven cavity problem
CO4	Derive numerical solutions of various convection-diffusion problems using various schemes
CO5	Analyse the performance of thermal turbomachines
CO6	Calculate the performance parameters of hydro turbomachines

2. Soft tool based and coding based practices

ANSYS-FLUENT

1. Introduction to mesh generation software (ICEM/Workbench)
2. Introduction to ANSYS-FLUENT solver
3. Fluid flow simulation through confined and unconfined passages (Laminar/ Turbulent)
4. Non-isothermal flow simulations through channel/enclosure/over bodies (Laminar + Turbulent)
5. Flow and associated scalar transport simulations for complex engineering applications
6. Multiphase transport modelling and simulation

CODING

1. FVM code for diffusion transport with and without source term
2. FVM code for advection-diffusion problem based on central difference scheme
3. FVM code for advection-diffusion problem based on upwind scheme
4. FVM code to analyse false-diffusion of upwind scheme
5. FVM code for advection-diffusion problem based on hybrid differencing scheme
6. FVM code for semi-explicit time marching of fluid flow problems
7. FVM code for semi-implicit time marching of fluid flow problems
8. Development of Coupled solvers for flow and associated transport
9. Introduction to Lattice Boltzmann Method (LBM)
10. LBM code for flow through confined and unconfined passages.

3. Laboratory Experiments:

1. Performance analysis of the centrifugal blower for three different vanes
2. Performance analysis of the centrifugal compressor
3. Performance analysis of high rpm centrifugal blower
4. Performance analysis of Hydraulic ram and Centrifugal pump
5. Performance analysis of Pelton turbine, Francis turbine and Kaplan turbine
6. Study of Schlieren and Shadowgraph flow visualization techniques.
7. Flow velocity measurements using intrusive and non-intrusive techniques
8. Study of flash point, fire point and auto ignition point
9. Analysis of modes of flames and different type of open flame burners
10. Study of different types of gas turbine combustion chamber

DEPARTMENT OF MECHANICAL ENGINEERING

M.TECH. (CAD/CAM)

SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY
Ichchhanath, Surat-395007, Gujarat, India
www.svnit.ac.in

MISSION & VISION STATEMENT OF INSTITUTE

Vision statement

To be one of the leading technical institutes disseminating globally acceptable education, effective industrial training and relevant research output.

Mission statement

To be a globally accepted center of excellence in technical education catalyzing absorption, innovation, diffusion and transfer of high technologies resulting in enhanced quality for all the stakeholders.

MISSION & VISION STATEMENT OF THE DEPARTMENT

Vision statement

Department of Mechanical Engineering, Sardar Vallabhbhai National Institute of Technology, Surat perceives to be globally accepted center of quality technical education based on innovation and academic excellence.

Mission statement

Department of Mechanical Engineering, Sardar Vallabhbhai National Institute of Technology, Surat strives to disseminate technical knowledge to its undergraduate, post graduate and research scholars to meet intellectual, ethical and career challenges for sustainable growth of humanity, nation, and global community.

PROGRAMME EDUCATIONAL OBJECTIVES (PEO)

The overall educational objective for **Master of Technology in CAD/CAM** is to educate students with excellent technical capabilities in the mechanical engineering discipline with the knowledge of computer aided design and manufacturing, who will be responsible citizens and continue their professional advancement through life-long learning.

As mechanical engineers with expertise in CAD/CAM, postgraduates are prepared with following educational objectives:

PEO1	To impart the knowledge of engineering subject matter incorporating computer as a tool and building a bright career in the area of design, simulation, manufacturing and production.
PEO2	To create technical ability in students by hands-on experience of design software to develop digital parts and CAM software to generate tool path for machining and conducting various experiments using latest infrastructure to enhance research approach.
PEO3	To construct the confidence by employing various learning resources for solving engineering / industrial problems, designing products for social economic issues to explore skill of entrepreneur.
PEO4	To develop professionalism to formulate and solve problems of interest individually and in team with high value of ethics.
PEO5	To apply an environment of communication through oral and written presentation of technical reports derived research reports so as to interact with academicians, researchers, and industrial practices.

PROGRAM OUTCOMES (PO)

PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PSO1	Design, analyse, formulate and solve engineering problems using computer software, tools and techniques.
PSO2	Adopt and demonstrate multidisciplinary approach to solve design, manufacturing and allied problems.

COURSE STRUCTURE FOR M. TECH. (CAD/CAM) AS PER NEP

SEMESTER –I

Code No	Subject	L	T	P	Exam Scheme			Total	Credits	Notional Hours of Learning (Approx.)
					Theory Marks	Tuto. Marks	Pract. Marks			
MECC101	**Core 1** Finite Element Methods	3	0	2	100	-	50	150	4	85
MECC103	**Core 2** Computer Aided Design	3	0	2	100	-	50	150	4	85
MECC105	**Core 3** Computer Aided Manufacturing	3	0	2	100	-	50	150	4	85
 MECC111 **MECC113** **MECC115** **MECC117** **MECC119**	**Core Elective 1** 1. Advanced Mechanics of Solids 2. Concurrent Engineering: Tools, Techniques and Applications 3. Computer Aided Production Planning 4. Condition Monitoring and Fault Diagnosis of Rotating Machinery 5. Material Characterization and Testing	3	0	0	100	-	-	100	3	55
 MECC121 **MECC123** **MECC125** **MECC127** **MECC129**	**Core Elective 2** 1. Fracture Mechanics 2. Product Design and Development 3. Industrial Robotics 4. Design of Pressure Vessels 5. Failure Analysis and NDE	3	0	0	100	-	-	100	3	55
MECC107	**Software Practice-I**	0	0	4			100	100	2	70
Total Credits/ Notional Hours of Learning									**20**	**435**
MECC191	**Vocational Training / Professional Experience (Optional) (Mandatory for Exit)**	2	0	0	*		100	100	5	80
MECC193		3	0	0	*		100	100		120

***As per requirement of professional courses, in case of industry placed student / vocational training or professional experience (5 credit)**

SEMESTER –II

Code No	Subject	L	T	P	Exam Scheme			Total	Credits	Notional Hours of Learning (Approx.)
					Theory Marks	Tuto. Marks	Pract. Marks			
MECC102	**Core 1** Computer Aided Machine Design	3	0	2	100	-	50	150	4	85
MECC104	**Core 2** Rapid prototyping and Tooling	3	0	0	100	-	-	100	3	55
 MECC112 **MECC114** **MECC116** **MECC118** **MECC120**	**Core Elective 3** 1. Design of Experiments 2. Instrumentation and Experimental Methods 3. Smart Materials and Manufacturing 4. Computer Aided Tool Design 5. Quality Engineering and Management	3	0	0	100	-	-	100	3	55
 MECC122 **MECC124** **MECC126** **MECC128** **MECC130**	**Core Elective 4** 1. Optimization Techniques 2. Theory of Elasticity and Plasticity 3. Industrial Tribology 4. Design and Analysis of Composite Structure 5. Surface Engineering	3	0	0	100	-	-	100	3	55
 MECC172 **MECC174**	**Institute Elective** 1. Extended Finite Element Methods 2. Computational Fluid Dynamics Techniques	3	0	0	100	-	-	100	3	55
MECC106	**Software Practice-II**	0	0	4			100	100	2	70
MECC108	**Mini Project**	0	0	4			100	100	2	70
Total Credits/ Notional Hours of Learning									**20**	**445**
MECC192	**Vocational Training / Professional Experience (Optional) (Mandatory for Exit Laboratory Practice 2**	2	0	0	*	-	100	100	5	80
MECC194		3	0	0	*	-	100	100		120

***As per requirement of professional courses, in case of industry placed student / vocational training or professional experience (5 credit)**

SEMESTER –III

Code No.	Subject	L	T	P	Exam Scheme			Total	Credits	Notional Hours of Learning (Approx.)
					Theory Marks	Tuto. Marks	Pract. Marks			
	MOOC course-I*								3/4	70/80
	MOOC course-II*								3/4	70/80
MECC295	**Dissertation Preliminaries**					-	350	350	14	560
Total Credits									**20/22**	**700/720**

- **Student have to choose the subject with recommendation of supervisor.**

SEMESTER -IV

Code No.	Subject	L	T	P	Exam Scheme			Total	Credits	Notional Hours of Learning (Approx.)
					Theory Marks	Tuto. Marks	Pract. Marks			
MECC296	**Dissertation**				-	-	600	600	20	800
Total Credits									**20**	**800**

CREDIT MATRIX

Category	Credits to be earned				
	Sem- I	Sem - II	Sem- III	Sem - IV	Total
Core Courses	12	7	-	-	19
Elective Courses	6	9	-	-	15
Software/ Laboratory	2	2	-	-	4
Dissertation	-	-	14	20	34
Mini Project	-	2	-	-	2
Vocational Training / Professional Experience (Optional) (Mandatory for Exit Laboratory Practice 2	*5*	*5*	-	-	*10*
MOOC course-I	-	-	3/4	-	3/4
MOOC course-II	-	-	3/4	-	3/4
Total Credits	20	20	20/22	20	80/82

MECC101	:	FINITE ELEMENT METHODS	L	T	P	Credits
			3	0	2	04

1. Course Outcomes (COs):

At the end of the course the students will be able to,

CO1	Explain the fundamental concepts of the theory of the finite element method.
CO2	Develop element characteristic equation and generation of global equation.
CO3	Apply suitable boundary conditions to a global equation for bars, trusses and beams.
CO4	Evaluate the governing FE equations for solving 1D and 2D problems.
CO5	Apply the FE analysis for practical applications in static and dynamic condition.
CO6	Apply the FE method for thermal, potential flow and transient problems.

2. Syllabus:

Introduction	**(05 Hours)**
Relevance of finite element analysis in design, Modeling and discretization, Interpolation, Elements, Nodes and degrees-of-freedom, Applications of FEA. One-Dimensional Elements and Computational Procedures: Bar elements, Beam elements, Bar and beam elements of arbitrary orientation, Assembly of elements, Properties of stiffness matrices, Boundary conditions, Solution of equations, Mechanical loads and stresses, Thermal loads and stresses.	
Basic Elements Truss and Beam	**(08 Hours)**
Interpolation and shape functions, Element matrices, Linear triangular elements (CST), Quadratic triangular elements, Bilinear rectangular elements, Quadratic rectangular elements, Solid elements, Higher order elements, Development of Truss equations, Development of beam equations, Nodal loads-stress calculations.	
Isoperimetric Elements	**(07 Hours)**
Bilinear quadrilateral elements, Quadratic quadrilaterals, Hexahedral elements, Numerical integration, Quadrature, Static condensation, Load considerations, Stress calculations, Examples of 2D and 3D applications.	
Finite Elements in Structural Dynamics Applications	**(10 Hours)**
Solid and Structural Mechanics Applications: One dimensional problem static analysis of trusses, Analysis of plates, Solid of revolution. Dynamic analysis: Dynamic equations, Mass and damping matrices, Natural frequencies and modes, Damping, Model methods, Ritz vectors, Component mode synthesis, Direct integration techniques, Explicit and implicit methods, Analysis by responses spectra	
Heat Transfer and Fluid Mechanics Applications	**(08 Hours)**
Heat Transfer, Element formulation, Reduction -nonlinear problems, Transient thermal analysis, Acoustic frequencies and modes, fluid structure interaction problems, Plane incompressible and rotational flows.	

FEA Applications in Other Fields	(07 Hours)
Applications of FEA in torsion, Potential flow seepage, Fluid flow in ducts.	

(Total Lecture Hours: 45)

List of Practical

1. Analysis of 2-D Truss.
2. Analysis of 2-D Frame.
3. Analysis of L Shaped Bracket.
4. Analysis of Square plate with circular hole.
5. Analysis of Solid.
6. Dynamic and Modal analysis of Cantilever beam.
7. Analysis of 2-D heat flow problem.
8. Analysis of 2-D transient heat flow in plate.
9. Simulation of flow over car body.

3. <u>Books Recommended:</u>

1	R. D. Cook. Concepts and applications of finite element analysis. John Wiley & Sons, 2007.
2	D. L. Logan. A first course in the finite element method. Cengage Learning, 2016.
3	J. N. Reddy. An introduction to the finite element method, Vol. 1221, New York: McGraw-Hill, 2004.
4	T. Chandrupatla, A. Belegundu. Introduction to finite elements in engineering. Cambridge University Press, 2021.
5	O. C. Zienkiewicz, R. L. Taylor, J. Z. Zhu. The finite element method: its basis and fundamentals. Elsevier, 2005.

MECC103	:	COMPUTER AIDED DESIGN	L	T	P	Credits
			3	0	2	04

1. Course Outcome (COs):

At the end of the course the students will be able to,

CO1	Understand the concept of computer graphics, drafting, and modelling using different commands and graphical user interface
CO2	Apply the concept of transformation for generating different positions of given problem with defined geometry
CO3	Create 3D models assemblies and generative drawings of a given engineering part or product
CO4	Apply the knowledge of programming for complex shape required in engineering for drafting or modelling
CO5	Determine the coordinates of space curves and parametric curves required for generating features in CAD models
CO6	Analyze surfaces based on different criteria's and process of creation

2. Syllabus:

Introduction to Computer Graphics	**(04 Hours)**
Basics of Computer Aided Design, Introduction to Computer graphics, DDA and Bresenham's algorithm for generating various figures, and basics of CAD/CAM hardware.	
Transformation of Geometries	**(10 Hours)**
2D Transformation of geometries and 3D Transformations for Translation, Rotation, Scaling, Symmetry, Reflection, and Homogeneous Transformations, Orthographic Projections, Axonometric Projections, Oblique Projections, Perspective Transformation.	
Parametric and Non-Parametric Curves	**(07 Hours)**
Representation of curves – Explicit and Implicit Equations Parametric and non-parametric Curves, Splines, Bezier, B-Splines and generation of surfaces and surfaces.	
Computer Aided Drafting and Modeling	**(12 Hours)**
Introduction to Drafting and modelling of solids, Coordinate system, Fundamentals of solid modeling, Customization, 3D sketches, Datum features, Modeling operation Strategy and creating features, Geometric constraints, Modeling aids & tools, Generalized, views, Presentation of dimensioning / tolerances/symbols & annotation, Associatively, Parent child relationship, Parametric design, Programming techniques in drafting/ modeling/analysis, Concept of computer animation, Properties calculation Hidden line and surface removal.	
Design of Surfaces	**(05 Hours)**
Surface design, and Surface analysis.	

Assembly of CAD Parts and Surface	(07 Hours)
Top down and Bottom up approaches of creating and assembly. Presentation of assembly.	

(Total Lecture Hours: 45)

List of Practical

1. Introduction to drafting technologies & drafting practice.
2. Introduction interfacing of drafting package using program techniques.
3. Sketching/Drafting of assigned problem using programming.
4. Practice for 3-D modeling.
5. Modeling of assigned problem.
6. Modeling using parametric relations.
7. Modeling using linkage options.
8. Practice for assembly creation.
9. Practice for view generation.
10. Model/View associatively

3. Books Recommended:

1	D. Hearn. Computer graphics, C version. Pearson Education India, 1997.
2	D. F. Rogers, J. A. Adams. Mathematical elements for computer graphics. McGraw-Hill, Inc, 1989.
3	I. Zeid. CAD/CAM theory and practice. McGraw-Hill Higher Education, 1991.
4	M. Chris. CAD/CAM: Principles, Practice and Manufacturing, Prentice Hall, 1999.
5	P. N. Rao. CAD/CAM: principles and applications. Tata McGraw-Hill Education, 2004.

MECC105	:	COMPUTER AIDED MANUFACTURING	L	T	P	Credits
			3	0	2	04

1. Course Outcomes (COs):

At the end of the course the students will be able to,

CO1	Explain fundamentals of CAM
CO2	Demonstrate work zero, machine zero, tool zeros, work offset, tool length offset, and cutter radius offset and canned cycles
CO3	Develop a CNC part program using cutter radius offset commands
CO4	Develop a CNC part program by applying various features, such as cutter radius offset, subprogram, mirror, canned cycles, and pocket cycles, of machining centre to reduce programming task.
CO5	Develop a NC/CNC part program manually and using CAD/CAM software for a given part drawing having multiple operations
CO6	Explain the Group Technology, Flexible Manufacturing System and CAPP with advantages and limitations

2. Syllabus:

Introduction to CAD, CAM, CIM, NC/CNC, DNC and Automation	**(02 Hours)**
Definition of CAD, CAM, CIM, NC, CNC, DNC. Understanding differences among these terms. Direct Numerical Control and Distributed Numerical Control. Automated manufacturing systems and basic types, manufacturing support systems.	
NC/CNC Machine Tools	**(04 Hours)**
Components of NC/CNC system, Specification of CNC system, Classification of CNC machines, Constructional details of CNC machines, Axis designation, CNC control loops.	
CNC Part Programming – Milling	**(25 Hours)**
Basic Programming terms, Programming format, Preparatory (G-Codes) and Miscellaneous (m-Codes) functions, Machine zero, work zero and tool zero, Work offsets, Tool length offset and setup methods, cutter radius offset, CNC milling cutter holder, Part programming for milling – linear and circular interpolation, subprogram, fixed cycles, mirrors commands, machining large hole pattern, polar coordinates, round and rectangular pocket machining and cycles.	
Automatically Programmed Tools (APT)	**(04 Hours)**
Introduction to APT, geometry and motion statements, programming for geometry, drill cycles, and hole pattern.	
Introduction to CAM software	**(03 Hours)**
Modeling, toolpath generation, simulation of toolpath, generating CNC program.	
Group Technology (GT), Flexible Manufacturing Systems (FMS) and Compute Aided Process Planning (CAPP)	**(07 Hours)**

Introduction to GT, implementation considerations, benefits and applications, GT methods - visual search method, production flow analysis, Parts classification and coding.
Introduction, General Considerations for FMS, types of FMS, Flexibilities, their measurements, Computer control in FMS, Automated material handling systems, AGVs, Automatic storage and retrieval systems, Manufacturing cells, cellular v/s flexible manufacturing.
Manual and computer aided process planning, steps, and types.

(Total Lecture Hours: 45)

List of Practical

1. Demonstration of CNC Milling machine with user interface and calculating the coordinates of given geometry in absolute end increment mode for cutter path.
2. Introduction of G codes and M codes and write the CNC part programming for a given geometry using linear, Circular interpolation.
3. Write CNC part program using cutter path co-ordinate for a geometry made of lines and arcs.
4. Write the CNC programming for a given geometry using Mirror and Subroutine.
5. Write the CNC programming for a given geometry using Polar Co-ordinate for drilling cycles.
6. Write the CNC programming for a given geometry using Tool Radius Compensation and Repeat loop for Peck drilling cycles.
7. Introduction and programming of canned cycles of milling machine.
8. Demonstration of AS/RS and AVG operation.

3. <u>Books Recommended:</u>

1	S. F. Krar, A. Gill. CNC: Technology and Programming, McGraw-Hill, 1989.
2	P. Smid. CNC programming handbook: a comprehensive guide to practical CNC programming. Industrial Press Inc, 2003.
3	S. K. Sinha. CNC Programming (FANUC Control), Galgotia Publications Pvt Ltd., 2011.
4	S. H. Suh, S. K. Kang, D. H. Chung, I. Stroud. Theory and design of CNC systems. Springer Science & Business Media, 2008.
5	M. P. Groover. Automation, production systems, and computer-integrated manufacturing. Pearson Education India, 2016.

MECC111	:	ADVANCED MECHANICS OF SOLIDS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to,

CO1	Illustrate the stress at a point and constitutive relations.
CO2	Analyze the transformation of stress and strain in 3D including the utilization of yield criteria.
CO 3	Design the curved beams for different types of stresses.
CO 4	Analyze the shear stresses in non- circular shafts.
CO 5	Estimate the bending stresses in un-symmetric straight beams.
CO 6	Analyze the strain at a point in rotating disks.

2. Syllabus:

Introduction	**(09 Hours)**
Stress definition and stress-traction relations; Deformation, strain definition, strain-displacement relation; Constitutive equations; Equilibrium and compatibility equations.	
Analysis of Stresses and Strains in rectangular and polar coordinates	**(12 Hours)**
Cauchy's formula, Principal stresses and principal strains, 3D Mohr's Circle, Octahedral Stresses, Hydrostatic and deviatoric stress, Two-dimensional problem solutions, Plane stress and plane strain, compatibility conditions. Advanced two-dimensional problems.	
Introduction to curvilinear coordinates	**(12 Hours)**
Generalized Hooke's law and theories of failure. Energy Methods. Bending of symmetric and unsymmetric straight beams, effect of shear stresses, curved beams, Shear centre.	
Torsion of prismatic solid sections	**(12 Hours)**
Prandtl stress function, thin-walled sections, circular, rectangular and elliptical bars, membrane analogy. Thick and thin-walled cylinders, Composite tubes, Rotating disks and cylinders.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	M. H. Sadd. Elasticity: theory, applications, and numeric, 3rd edition, Academic Press, 2014.
2	L. S. Srinath. Advanced mechanics of solids, 3rd Edition, McGraw-Hill, 2009.
3	R. G. Budynas. Advanced Strength and Applied Stress Analysis, 2nd Edition, McGraw Hill, 2017.
4	P. Boresi, R. J. Schmidt. Advanced Mechanics of Materials, 6th Edition, John Willey and Sons,1985.
5	F. P. Beer, E. R Johnston. Mechanics of Materials | 8th Edition (in SI Units), McGraw Hill.

MECC113	:	CONCURRENT ENGINERING: TOOLS, TECHNIQUES AND APPLICATIONS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to,

CO1	Support the multi-disciplinary integrated product development teams and Plan and implement a new product development program.
CO2	Apply appropriate concurrent engineering tools and techniques to design and develop environment-friendly products by leveraging both manufacturing cost and lifecycle cost.
CO3	Determine the customer needs and ensure that the product design is robust and meets the professional standards with better quality.
CO4	Design and develop the products with high reliability, maintainability, and availability.
CO5	Apply the information technology tools for collaborative product design and development.
CO6	Demonstrate the applications of concurrent design of structures, products and components.

2. Syllabus:

Introduction	**(07 Hours)**
Motivation, definition, and philosophy of Concurrent Engineering (CE); sequential and concurrent processes; Principles of CE; Organizing for CE; CE teams and team dynamics; Role of CAD/CAM/CAE/CIM and automation in CE; Managing product development projects; Decomposition of product development stages; Benefits of CE; Implementation issues of CE.	
Concurrent Engineering Tools and Techniques	**(10 Hours)**
Design for manufacturing (DFM), Design for assembly (DFA); Factors influencing form design; Casting and machining considerations; Design for manufacturing and Assembly (DFMA) guidelines and examples; Lifecycle design of products with circular economy concept; Design for environment (DFE) with examples; Design for (-to-)cost; Design for X (DFX); Value engineering.	
Design for quality; Taguchi's methods for designing robust products; Design of Experiments (DOE) with examples; Design optimization; Quality function deployment (QFD) with examples.	**(06 Hours)**
Design for reliability, maintainability and availability with examples; Failure modes and effects analysis (FMEA); Fault tree analysis (FTA); Rapid prototyping methods; Design simulation; Virtual and augmented reality environments for CE.	**(08 Hours)**
Role of Information Technology In Concurrent Engineering Information technology (IT) components and functions; Artificial Intelligence for IT	**(07 Hours)**

operations used for product design; Collaborative product development; Collaborative product commerce, Cloud IoT for CE.	
Selected Applications of Concurrent Engineering	**(07 Hours)**
Design of aerospace and naval structures made of composite materials; Design of automotive components; Design of medical devices; Design of electronic products; Design of white goods parts.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	B. Prasad. Concurrent Engineering Fundamentals I & II, Prentice Hall, New Jersey, 1996.
2	I. Moustapha. Concurrent Engineering in Product Design and Development, New Age International, New Delhi, 2006.
3	G. Boothroyd, P. Dewhurst, W. Knight. Product Design for Manufacture and Assembly, 3rd Edition, Routledge, Boca Raton, 2010.
4	J. R. Hartley. Concurrent Engineering: Shortening Lead Times, Raising Quality, and Lowering Costs, 4th Edition, Routledge, Boca Raton, 2017.
5	K. T. Ulrich, S. D. Eppinger, M. C. Yang. Product Design and Development, 7th Edition, McGraw Hill Education (India), Noida, 2020.

MECC115	**:**	**COMPUTER AIDED PRODUCTION PLANNING**	**L**	**T**	**P**	**Credits**
			3	**0**	**0**	**03**

1. Course Outcomes (COs):

At the end of the course the students will be able to,

CO1	Explain different methods of computer aided process planning (CAPP) and distinguish between process planning and production planning.
CO2	Determine the forecast of a product for the given historical data using forecasting models.
CO3	Solve the facility layout problems using different algorithms and create part families and machine cells in a manufacturing facility using group technology approach.
CO4	Evaluate material requirement plan for a product and explain enterprise resource planning (ERP).
CO5	Create schedules for multiple machines/workstations and describe the capacity planning.
CO6	Explain different computer aided measurement and inspection techniques.

2. Syllabus:

Introduction	**(05 Hours)**
Production systems and their types -mass production, batch production and job shop production systems. Introduction to process planning in manufacturing, Role of process planning. Computer aided process planning (CAPP) - variant and generative type process planning.	
Computer Aided Forecasting	**(06 Hours)**
Introduction to forecasting, sources of data, demand patterns, forecasting errors, forecasting models – Quantitative: moving average, linear regression and exponential smoothing methods; Qualitative - Delphi method.	
Facility Layout Planning	**(10 Hours)**
Introduction to facility layout, objectives, types of facility layout- line layout, process layout, cellular layout and fixed position layout, advantages and disadvantages. Assembly line balancing, line balancing algorithms- largest candidate rule, Kilbridge and Wester method, and ranked positional weights method. Heuristics of process layout problems - computerized relative allocation of facility technique, automated layout design program and computerized relationship layout planning. Multi objective approach for facility layout planning.	
Group Technology	**(06 Hours)**
Introduction, benefits of group technology, part families, part classification and coding, applications of GT. Algorithms and models for Group Technology - Rank order clustering algorithm and Bond energy algorithm.	
Material Requirement Planning	**(06 Hours)**

Introduction, Objective of the MRP system, inputs to the MRP System – product structure or bill of materials (BOM), master production schedule (MPS) and inventory status file. MRP calculations. Manufacturing resources planning (MRP-II). Enterprise resource planning (ERP).	
Scheduling and Capacity Planning	**(07 Hours)**
Introduction, Single machine scheduling –shortest processing time rule, weighted mean flow time rule, earliest due date rule, model to minimize total tardiness, branch and bound algorithm. Introduction to parallel processors under single machine scheduling. Flow shop scheduling – Johnson's algorithm. Job shop scheduling. Capacity planning – measure of capacity, capacity strategies, tools for capacity planning.	
Computer Aided Measurement and Inspection	**(05 Hours)**
Computer Aided Testing, Contact and Non-contact type inspection, Co-ordinate measuring machines (CMM), types of CMM, Applications of CMM and its Benefits, Laser viewers for production profile checks, Machine vision technology, Microprocessors in metrology.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	R. Panneerselvam. Production and Operations Management, 3rd Edition, PHI Learning Pvt Ltd, 2015.
2	M. P. Groover. Automation production systems and computer integrated manufacturing, 5th edition, Pearson Edu Ltd, 2019.
3	E. E. Adam, R. J. Ebert. Production and Operations Management, 5th Edition, Prentice Hall of India, 2015.
4	J. Heizer, B. Render, C. Munson. Operations Management, Pearson Edu Ltd, 12th Edition, 2017.
5	S. N. Chary. Production and operations management, McGraw Hill Education (India) Pvt. Ltd, 6th Edition, 2019.

MECC117	**:**	**CONDITION MONITORING AND FAULT DIAGNOSIS OF ROTATING MACHINERY**	**L**	**T**	**P**	**Credits**
			3	**0**	**0**	**03**

1. <u>Course Outcomes (COs):</u>

At the end of the course the students will be able to

CO1	Describe basic terminologies used in condition monitoring of rotating machinery.
CO2	Examine vibration analysis problems of complex rotating systems.
CO3	Understand and analyze rotor systems with non-linear effects included.
CO4	Identify and analyze rotating machinery faults using different methods.
CO5	Illustrate the utility of instrumentation and terminology used in signal analysis for fault detection in rotating machinery.
CO6	Analyse various plots used in condition monitoring of rotors to predict rotor faults.

2. <u>Syllabus:</u>

Introduction To Condition Monitoring	**(09 Hours)**
Introduction to condition monitoring, Maintenance approach, Basics of machinery vibration, Conventions and characteristics - amplitude, frequency and phase.	
Vibration Analysis Of Complex Rotating Systems	**(12 Hours)**
Asymmetric rotors, Axial vibrations, Torsional vibration - Holzer`s method, Transfer Matrix method, Geared and Branched systems, Effect of isotropic and anisotropic supports, Alford force, Whirling of rotor, Campbell diagram, Overhung rotors, Morton effect, Temperature effect on vibration.	
Rotating Machinery Faults And Detection	**(14 Hours)**
Rotating machinery faults and its detection - Unbalance, Misalignment, Bent rotors, Bearing defects,Oil Whirl, Oil whip, Looseness, Electric motor defect, Rotor stator rub etc., frequency range of faults, Non-destructive testing, Acoustic emission technique and applications, Introduction to Active magnetic bearing.	
Instrumentation And Signal Analysis	**(10 Hours)**
Instrumentation and Fault Detection Transducers - Displacement, Velocity and Acceleration, Computer aided data acquisition, Oscilloscope, Vibration Exciter systems, Signal Analysis,Basics of FFT, Trend plot, Time domain plot, Frequency domain plot, Spectrum plot, Waterfall plot, RMS, Peak and Peak-peak value, Case studies - Spectrum interpretation charts.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Michael I. Friswell, John E. T. Penny, Seamus D. Garvey, Arthur W. Lees. Dynamics of Rotating Machines, Cambridge University Press, 2010.
2	A. Davies. Handbook of Condition Monitoring: Techniques and Methodology, Springer Science & Business Media.
3	R. Isermann. Fault diagnosis applications, Springer – Verlag, Berlin.
4	W. T. Thomson. Theory of Vibration with Applications, CBS Publishers and Distributors, New Delhi.
5	J. S. Rao. Rotor Dynamics, New Age International Ltd.

MECC119	:	MATERIAL CHARACTERIZATION AND TESTING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to,

CO1	Understand importance of Materials characterization techniques.
CO2	Describe principles of operation and uses of Thermal analysis equipment.
CO3	Explain the production of X-rays, electrons and the electron-specimen interaction mechanisms.
CO4	Describe fundamental principles of operation of four materials characterization techniques, namely optical microscopy, scanning electron microscopy, transmission electron microscopy and scanning probe microscopy.
CO5	Analyze the micro and nano-images obtained with the different materials characterization techniques to the behavior of materials and their mechanical properties.
CO6	Understand importance of various non-destructive evaluation for material Characterization.

2. Syllabus:

Importance of Material Characterisation	**(02 Hours)**
Classification of techniques for characterization, macro and micro characterization structure of solids, Basic principles & concepts.	
Thermal analysis Technique and Metallographic techniques	**(05 Hours)**
Introduction, Instrumentation, experimental parameters, Different types used for analysis, Thermo gravimetry, Differential thermal analysis, Differential Scanning Calorimetry, Basic principles, Instrumentation, working principles, Applications, Limitations.	
Diffraction Method	**(05 Hours)**
Braggs Law, X ray Diffraction methods, Determination of crystal structure, Lattice Parameter, Residual Stress, crystallite size, Applications, Limitations.	
Microscopy	**(06 Hours)**
Optical Microscopy **-** Introduction, Optical principles, Instrumentation, Specimen preparation, quantitative metallography Interaction of electron beam with materials; scanning electron microscopy– construction and working of SEM, various imaging techniques, applications; FESEM transmission electron microscopy - specimen preparation for TEM; applications of TEM; various imaging techniques, applications, Applications, Limitations.	
Spectroscopy Techniques for Chemical Analysis	**(06 Hours)**
Atomic absorption spectroscopy, X-ray spectrometry, infrared spectroscopy, XRF, UV-Visual (UV-VIS), IR, and Raman spectroscopy. Mass spectroscopy: Principles and brief account, EDS, WDS, EPMA Instrumentation, Working procedure, Applications, Limitations.	

Surface Characterisation	**(07 Hours)**
XPS(ESCA), UPS, Auger Electron Spectroscopy, Electron Probe Microanalysis (EPMA), Working procedure, Applications, Limitations.	
Nano-mechanical characterization	**(07 Hours)**
AFM, STM and Nano indentation studies, Introduction, Basic principles - applications and limitations.	
Non-Destructive testing	**(07 Hours)**
Introduction, Liquid penetrant inspection, Magnetic particle inspection, Ultrasonic inspection, Eddy current inspection, X-ray radiography.	

(Total Lecture Hours: 45)

3. <u>Books Recommended:</u>

1	S. Zhang, Lin Li, A. Kumar. Materials Characterisation Techniques, CRC press, 2008.
2	Y. Leng. Materials Characterisation: Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia), 2013.
3	D. A. Skoog, F. J. Holler, S. R. Crouch. Instrumental analysis (Vol. 47). Belmont: Brooks/Cole, Cengage Learning, 2017.
4	W. Kemp. Organic Spectroscopy, 3rd ed., Palgrave Macmillan, 2019.
5	C. R. Brundle, C. A. Evans, S. Wilson. Encyclopedia of Materials Characterisation, Butterworth-Heineman, 1992.

MECC121	**:**	**FRACTURE MECHANICS**	**L**	**T**	**P**	**Credits**
			3	**0**	**0**	**03**

1. Course Outcomes (COs):

At the end of the course the students will be able to

CO1	Explain the basic, principals of fracture mechanics.
CO2	Explain the theory of elasticity and plasticity.
CO3	Evaluate the stress intensity factor by various methods.
CO4	Solve the problems on J-integral and crack arrest
CO5	Analyse the different modes of fracture.
CO6	Apply the fracture analysis on practical applications.

2. Syllabus:

Overview of Fracture Mechanics	**(10 Hours)**
Introduction and history, kinds of failure, brittle and ductile fracture, modes of fracture, Defects and cause of defects in the materials, Different types of loadings, Fracture Mechanics and the Energy Balance Approach, Micro and macro crack. Stress concentration due to hole. Case study of failure of structures due to fracture.	
The Energy Release Rate	**(08 Hours)**
Griffith analysis, Criteria for crack growth, The crack resistance (R curve), Compliance, Stability, Fracture beyond general yield. The Crack-tip opening displacement. The Use of CTOD criteria. Experimental determination of CTOD, energy release rate.	
Stress Intensity Factor	**(09 Hours)**
Linear Elastic Fracture Mechanics, Crack in plate with finite dimension, edge crack, embedded crack, First mode, second mode and mixed mode stress intensity factor, relation between stress intensity factor (SIF) and energy release rate (G) and critical stress intensity factor, Westergaard's approach, Numerical examples on the evaluation of different SIF.	
J Integral, Dynamics and Crack Arrest	**(09 Hours)**
Concept of J integral. Limitation of J integral. Experimental determination of J integral and the parameters affecting J integral. Crack speed and kinetic energy. Dynamic stress intensity and elastic energy release rate. Crack branching. Principles of crack arrest. Crack arrest in practice. Dynamic fracture toughness.	
Crack Propagation and Applications of Fracture Mechanics	**(09 Hours)**
Crack growth and the stress intensity factor. Factors affecting crack propagation, Paris law, Required information for fracture mechanics approach and engineering applications of fracture mechanics.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	P. Kumar. Elements of fracture mechanics, Tata McGraw Hill, New Delhi, 2017.Mc Graw Hill Education, 2009.
2	T. L. Anderson. Fracture Mechanics-Fundamental and Application, CRC Press, Fourth Edition, 2017.
3	D. Broek. Elementary Engineering Fracture Mechanics, Kluwer Academic Publications, Fourth Edition, 2011
4	K. Hellan. Introduction to fracture mechanics, McGraw Hill, 2nd Edition, 2016.
5	S. K. Maiti. Fracture mechanics: Fundamentals and Applications, Cambridge University Press, First edition, 2015

MECC123	:	PRODUCT DESIGN AND DEVELOPMENT	L	T	P	Credits
			3	0	2	04

1. Course Outcomes (COs):

At the end of the course the students will be able to,

CO1	Illustrate the importance of conceptual design to the product development.
CO2	Apply the market research analysis to identify customer needs.
CO3	Apply the creative thinking tools for the development of new design concepts.
CO4	Analyse the optimal design concept using decision making methodology.
CO5	Illustrate the embodiment design and robust design concepts.
CO6	Analyse the various factors like human and cost in relation to industrial design.

2. Syllabus:

Need for Developing Products	**(15 Hours)**
The importance of engineering design, types of design, the design process, relevance of product lifecycle issues in design, designing to codes and standards, societal considerations in engineering design, generic product development process, various phases of product development, planning for products, establishing markets, market segments, relevance of market research **Identifying Customer Needs** Voice of customer, customer populations, hierarchy of human needs, need gathering methods, affinity diagrams, needs importance, establishing engineering characteristics competitive benchmarking, quality function deployment, house of quality, product design specification, case studies.	
Creative Thinking	**(15 Hours)**
Creativity and problem solving, creative thinking methods, generating design concepts, systematic methods for designing, functional decomposition, physical decomposition, functional representation, morphological methods, TRIZ axiomatic design. **Decision Making** Decision theory, utility theory, decision trees, concept evaluation methods, Pugh concept selection method, weighted decision matrix, analytic hierarchy process, introduction to embodiment design, product architecture, types of modular architecture, steps in developing product architecture.	
Industrial Design	**(15 Hours)**
Human factors design, user friendly design, design for serviceability, design for environment, prototyping and testing, cost evaluation, categories of cost, overhead costs, activity based costing, methods of developing cost estimates, manufacturing cost, value analysis in costing.	

(Total Lecture Hours: 45)

3. Books recommended:

1	K. T. Ulrich and S. D. Eppinger. Product Design and Development, McGraw-Hill Education, 2016
2	C. L. Dym, P. Little and E. Orwin. Engineering Design: A Project-Based Introduction, 4th Edition, John Wiley & Sons Inc., 2013.
3	G. E. Dieter and L. C. Schmidt. Engineering Design, McGraw-Hill International Edition, 2013.
4	A. Jamnia. Introduction to Product Design and Development for Engineers, CRC Press, 2018.
5	K. Prashant. Product Design: Creativity, Concepts and Usability, PHI Learning Private Limited, 2012.

MECC125	:	INDUSTRIAL ROBOTICS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to,

CO1	Explain the basics of robotic systems.
CO2	Apply the concept of robot arm kinematics.
CO3	Analyze statics and dynamics of robots.
CO4	Analyze manipulator trajectories.
CO5	Analyze control of robot manipulators.
CO6	Illustrate robot programming, sensing and vision.

2. Syllabus:

Introduction	**(04 Hours)**
Introduction to robots, Robot manipulators, Robot anatomy, Coordinate systems, Work envelope, Types and classification, Specifications, Actuators and drives.	
Mathematical Representation of Robots	**(05 Hours)**
Rotations and translation of vectors, Transformations and Euler angle representations, Homogenous transformations, Representation of position and orientation of a rigid body, Homogeneous transformations, Denavit-Hartenberg (D-H) notations and parameters, Representation of joints, link representation using D-H parameters.	
Forward and Inverse Kinematics	**(10 Hours)**
Introduction, Forward and inverse kinematics problems, Velocity and Statics analysis, Linear and angular velocity of links, Velocity propagation, Jacobians for robotic manipulators, Statics and force transformation of robotic manipulators, Singularity analysis.	
Robot Dynamic analysis	**(05 Hours)**
Introduction, Forward and inverse dynamics, Mass and inertia of links, Lagrangian formulation for equations of motion for robotic manipulators, Newton-Euler formulation method.	
Trajectory Planning and Control	**(11 Hours)**
Joint and Cartesian space trajectory planning and generation, Classical control concepts using the example of control of a single link, Independent joint PID control, Control of a multi-link manipulator, Nonlinear model based control schemes.	
Force Control of manipulators	**(03 Hours)**
Hybrid position/force control.	
Robot Programming, Sensing and Vision	**(07 Hours)**
Robot Programming, Introduction to sensing and vision in robotics.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	A. Ghosal. Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2006.
2	J. J. Craig. Introduction to Robotics: Mechanics and Control, 4th edition, Pearson, 2018.
3	R. J. Schilling. Fundamentals of Robotics Analysis and Control, Pearson Education India, 2015.
4	K. S. Fu, R. C. Gonzalez, C. S. G. Lee. Robotics: Control, Sensing, Vision, and Intelligence, McGraw Hill, 1987.
5	S. K. Saha. Introduction to Robotics, McGraw Hill Education India, 2014.

MECC127	**:**	**DESIGN OF PRESSURE VESSELS**	**L**	**T**	**P**	**Credits**
			3	**0**	**0**	**03**

1. Course Outcomes (COs):

At the end of the course the students will be able to

CO1	Describe the factors influencing the design of pressure vessels.
CO2	Calculate the different stresses and strains in a pressure vessel.
CO3	Design the head and shell for the pressure vessel
CO4	Estimate the stresses in the nozzle and its reinforcement
CO5	Analyze the critical part of pressure vessels.
CO6	Evaluate the buckling pressure and type of failure

2. Syllabus:

Introduction:	**(04 Hours)**
Factors influencing the design of vessels**,** Classification of pressure vessels, Material selection, Loads and types of failures.	
Stresses in pressure vessels:	**(13 Hours)**
Stresses in circular ring, Cylinder and sphere, Membrane stresses in vessels under internal pressure, Thick cylinders, Shrink-fit stresses, Autofrettage of thick cylinders, Thermal stresses.	
Design Of Heads	**(05 Hours)**
Introduction, Design for hemispherical head, Ellipsoidal head, Torispherical head, Conical and toriconical head, Flat heads and covers.	
Design of Nozzles and Openings	**(05 Hours)**
Introduction, Stress concentration about a circular hole, Cylindrical and spherical shell with circular hole under internal pressure, Nozzles in pressure vessels.	
Discontinuity Stresses in Pressure Vessel	**(11 Hours)**
Introduction, Beam on elastic foundation, infinitely long beam, Semi-Infinite beam, Cylindrical vessel under axially symmetrical loading, Extent and significance of load deformations on pressure vessels, Stresses built in a bimetallic joint, Deformation and stresses in flanges	
Buckling of Vessels	**(07 Hours)**
Buckling phenomenon, Elastic Buckling of circular ring and cylinders under external pressure, Collapse of thick walled cylinders or tubes under external pressure, Effect of supports on Elastic buckling of cylinders, Buckling under combined External pressure and axial loading	

(Total Lecture Hours: 45)

3. Books Recommended:

1	J. F. Harvey. Theory and Design of Pressure Vessels, Springer US, 2007.
2	S. Chattopadhyay. Pressure Vessels: Design and Practice, CRC Press, 2004.
3	Lloyd E. Brownell, Edwin H. Young, Process Equipment Design, Wiley Interscience, 1966
4	A. S. Tooth. Pressure Vessel Design: Concepts and Principles, 1st Edition, CRC Press, 2012.
5	D. R. Moss, M. M. Basic. Pressure Vessel Design Manual, 4th Edition, Elsevier Science, 2012.

MECC129	:	FAILURE ANALYSIS AND NDE	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to

CO1	Develop knowledge about the basic concept of material selection
CO2	Define tools and techniques of failure analysis, procedural steps for investigation of failure and failure data retrieval.
CO3	Identify the different fracture modes and their characteristics.
CO4	Understand and be able to identify the common modes of failure of engineering components
CO5	Apply understanding to relevant case studies and identify failure mechanisms.
CO6	Understand concept of Non Destructive evaluation and its applications for Failure analysis

2. Syllabus:

Introduction	**(06 Hours)**
Philosophy of material selection, motivation for selection, relationship to available resources, concept of resource base, Criteria for selection of engineering materials. Case studies in material selection like materials for bearings, gears, automobile structures, aircraft components, ship structures.	
General Procedures for Failure Analysis	**(06 Hours)**
Sources of Failures, Steps in Failure Analysis, collection of data and samples; preliminary examination; non-destructive inspection; mechanical testing; selection and preservation of fracture surfaces; macroscopic and microscopic examination; selection; preparation and examination of metallographic sections; fracture classification; report writing.	
Failure of brittle and ductile material	**(07 Hours)**
Details of fractographic, Crack initiation and propagation in ductile and brittle material, Griffith theory, Irwin's modification, surface and embedded cracks, Surface treatments to minimize the surface cracks, Crack growth mechanism for plane stress and plain strain, Notch sensitivity, stress tri-axiality, Failure due to tension and torsion, Modulus of rupture, stress intensity factor.	
Fatigue Failures	**(05 Hours)**
factors affecting fatigue life; stages of fatigue fracture; fatigue cracking; effects of variables; mean stress; stress concentration; metal characteristics; manufacturing process; elevated temperature fatigue; contact fatigue.	
Types of corrosion	**(06 Hours)**

Stress Corrosion, corrosion cracking, Analysis of corrosion failure, Procedure for analysis of stress corrosion cracking. Effect of Environment. Analysis of corrosion characteristics of metals and alloys in different environment. Types of wear, Role of friction, Interaction of corrosion and wear. Analysis of wear failure.	
Elevated-Temperature Failures	**(05 Hours)**
creep; stress rupture; thermal fatigue; effect of atmospheric environment; failures in industrial application; testing techniques.	
Case studies in failure analysis	**(05 Hours)**
Case histories of component failures. Typical case studies of failure of important components such as gears, shafts, pressure vessels etc. Prevention of failures.	
Non-destructive testing (NDT)	**(05 Hours)**
Principle and methodology of different NDT methods, Liquid Penetration Testing, Ultrasonic Testing, Radiographic Testing, Magnetic Particle Testing.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	R. B. Charlie, A. Choudhury. Failure Analysis of Engineering Materials, McGraw Hill Education, 2002.
2	R. W. Hertzberg, R. P. Vinci, J. L. Hertzberg. Deformation and fracture mechanics of engineering materials. John Wiley & Sons, 2020.
3	V. Ramachandran. Failure analysis of engineering structures: methodology and case histories. ASM International, 2005.
4	ASM Handbook, Failure Analysis and Prevention, Volume 11, 2002, .ASM International.
5	L. D. C. F. Canale, G. E. Totten, R. A. Mesquita. Failure analysis of heat treated steel components. ASM international, 2008.

MECC107	**:**	**SOFTWARE PRACTICE -I**	**L**	**T**	**P**	**Credits**
			0	**0**	**4**	**02**

1. <u>Course Outcomes (COs):</u>

At the end of the course the students will be able to:

CO1	Understand the GUI and tool related to sketch and 3D Modelling.
CO2	Develop sketch by using space curve and different commands.
CO3	Create 3D model using suitable features.
CO4	Develop assembly of a given part.
CO5	Create drawing of given component and assembly.
CO6	Create animations of a given product.

<u>Exercises</u>:

1. Drafting/Modelling of given 2D/3D model.
2. Develop assembly of a given product.
3. Motion Simulation of a given product.
4. To create production drawing of a given object or product.
5. To create drawing of exploded assembly views.
6. To create bill of materials and balloons of a product drawing.

MECC102	:	COMPUTER AIDED MACHINE DESIGN	L	T	P	Credits
			3	0	2	04

1. Course Outcomes (COs):

At the end of the course the students will be able to

CO1	Understand the engineering design process and its role in machine elements.
CO2	Analyze and interpret the design of shafts and its applications.
CO3	Understand various gear and gear boxes problem.
CO4	Explain design requirements of mechanical brake and clutch.
CO5	Explain the design requirements of sliding and rolling contact bearings and their applications.
CO6	Create a technical drawing & model for given part or assembly using given CAD software.

2. Syllabus:

Introduction	**(10 Hours)**
Phases of design, Standardization and interchangeability of machine elements, Tolerances from process and function, Individual and group tolerances, Selection of fits for different design situations, Design for assembly and modular constructions, Concepts of integration.	
Shafting	**(10 Hours)**
Analysis and Design of shafts for different applications, detailed design, Preparation of production drawings, integrated design of shaft, Bearing and casing, Design for rigidity.	
Gears and Gear Boxes	**(12 Hours)**
Principles of gear tooth action, Gear correction, Gear tooth failure modes, Stresses and loads, Component design of spur, helical, Bevel and worm gears, Deign for sub assembly, Integrated design of speed reducers and multi-speed gear boxes, application of software packages.	
Clutches and Brakes	**(13 Hours)**
Integrated design of automobile clutches and over running clutches. Dynamics and thermal aspects of vehicle braking – Integrated design of brakes for machine tools, automobiles and mechanical handling equipment.	

(Total Lecture Hours: 45)

List of practical :

1. Practice/Study of Programming Language C, C++, VB, Python, etc.
2. Computer Aided Design of Shafts under Different Loading Conditions.
3. Computer Aided Design of Spur Gear.
4. Computer Aided Design of Helical Gear.
5. Computer Aided Design of Worm Gear.
6. Computer Aided Design of Bevel Gear.
7. Optimum Design of kinematics layout of Gear boxes.
8. Computer Aided Design of Brakes.
9. Computer Aided Design of Clutches
10. Computer Aided Design of Material Handling Equipment

3. Books Recommended:

1	W. C. Orthwein. Clutches and Brakes: Design and Selection, 2nd Edition, Taylor & Francis, 2004.
2	R. C. Juvinall and K. M. Marshek. Fundamentals of Machine Component Design, Wiley India, 2020.
3	G. M. Maitra. Handbook of Gear Design, 2nd Edition, Tata McGraw Hill, 1994.
4	R. G. Budynas and J. K. Nisbett. Shigley's Mechanical Engineering Design, McGraw Hill Publications, 2016.
5	Design Data: Data Book of Engineers, P. S. G. College of Technology, Revised Edition, Coimbatore, 2016.

MECC104	:	RAPID PROTOTYPING AND TOOLING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to

CO1	Analyze the role of rapid prototyping in product development cycle and Recommend scope of improvements in product development.
CO2	Integrate design concepts with CAD or reverse engineering for geometry preparation for Rapid prototyping of part.
CO3	Identify defects in the data for rapid prototyping and propose necessary improvements.
CO4	Analyze the working of different rapid prototyping systems and recommend suitable process for a given material and application.
CO5	Explain the concept of rapid tooling.
CO6	Analyze the process chain of different rapid prototyping systems and Create a pathway for rapid manufacturing.

2. Syllabus:

Introduction	**(02 Hours)**
CAD-CAM and its integration, Development of CAD CAM, The importance of being Rapid, Rapid Prototyping (RP) Defined, Time compression Technologies, Product development and its relationship with rapid prototyping, Process chain for rapid prototyping.	
Reverse Engineering	**(04 Hours)**
Reverse Engineering and CAD model, Digitizing Techniques: Mechanical Contact Digitizing, Optical Non-contact Measurement, CT Scanning Method, Data Processing for Surface Reconstruction, Software for Reverse Engineering, Case studies.	
Data Preparation For Rapid Prototyping	**(10 Hours)**
STL interface Specification, STL data generation, STL data Manipulation, Advantages and limitations of STL file format, Open files, Repair of STL files, Alternative RP interfaces, Part orientation and support generation, Factors affecting part orientation, Various models for part orientation determination, The function of part supports, Support structure design, Automatic support structure generation. Model Slicing and Contour Data organization, Direct and adaptive slicing: Identification of peak features, Adaptive layer thickness determination, Tool path generation.	
Liquid Based Rapid Prototyping Processes	**(06 Hours)**
Photo polymerization, principle and working of stereo lithography apparatus, scanning techniques, curing processes, Mask Projection based RP systems, Two Photon Vat Photo polymerization, Typical materials and applications.	

Powder Based Rapid Prototyping Processes	**(10 Hours)**
Powder fusion mechanism, powder handling and recycling, Principle and working of Selective Laser Sintering, Laser Engineering Net Shaping process, Electron Beam Melting, Binder Jet 3D Printing, process parameters, Typical materials and applications.	
Solid Based Rapid Prototyping Processes	**(07 Hours)**
Basic principle and working of fused deposition modelling process, liquification, solidification and bonding, bio extrusion, Laminated Object Manufacturing process, Wire and Arc based RP system, Typical materials and applications.	
Rapid Tooling	**(06 Hours)**
Classification of Rapid Tooling (RT) Routes, RP of Patterns, Indirect RT: Indirect method for Soft and Bridge Tooling, Indirect method for Production Tooling, Direct RT: Direct RT method for Soft and Bridge Tooling, Direct method for Production Tooling, Other RT Approaches. Rapid Manufacturing: Methods, limitations.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	D. Gibson, Rosen, B. Stucker. Additive Manufacturing Technologies, Springer Publisher,2010.
2	C. K. Chua, K. F. Leong, C. S. Lim. Rapid Prototyping – Principles and Applications, World Scientific, 3rd Edition, 2010.
3	K. V. Patri and M. Weiyin. Rapid Prototyping: Laser-based and Other Technologies, Springer Publisher, 2004.
4	R. Noorani. 3D Printing Technology, Applications and Selection, CRC Press, 2017.
5	M. W. M. Cunico. 3D Printers and Additive Manufacturing: The Rise of The Industry 4.0, Concept 3D, 2019.

MECC112	:	DESIGN OF EXPERIMENTS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to

CO1	Explain the fundamentals of Design of Experiments (DoEs).
CO2	Design and conduct experiments for developing linear model and analyse the resulting data to obtain valid conclusions and optimize the system.
CO3	Identify optimal or good designs for developing nonlinear model efficiently and effectively, and analyse the resulting data to obtain valid conclusions and optimize the system.
CO4	Explain and construct design matrix for conducting experiments for linear and nonlinear model.
CO5	Explain and apply Taguchi´s robust design methodology for mechanical engineering problems.
CO6	Create standard design and custom design as per situations, and analyse the data for valid conclusions using software

2. Syllabus:

Introduction to Design and analysis of experiments	**(04 Hours)**
Basic Principles of Design and Analysis of Experiments, Guidelines for Designing Experiments, model of a system, types of experimental design (first-order and second-order model), basic statistical concepts, single factor experiments.	
Linear experimental designs and optimization	**(16 Hours)**
Basic definition and principles, 2^k full factorial design, a geometrical representation, standard order form, first order response surface model, estimation of main and interaction effects, statistical analysis, estimation of parameters and model adequacy test, 2^{k-p} fractional factorial design, steps to construct fractional factorial design, first order response surface model, estimation of main and interaction effects, statistical analysis, estimation of parameters and model adequacy test, screening designs.	
Non-linear experimental designs and optimization	**(12 Hours)**
Basic definition and principles, 3^k full factorial design, central composite designs, Box-Behnken design, estimation of linear and nonlinear effects, a second order response surface model, sequential approach.	
Taguchi Design	**(05 Hours)**
Introduction to Taguchi design, orthogonal arrays (OA), properties of OA, design of OA, Concept of S/N ratio.	
Software Practice	**(08 Hours)**

Introduction to software used for design and analysis of experiments, systematic analysis and steps involved in software for the analysis of factorial design, fractional factorials method, Taguchi method and response surface methodology, case studies and examples.

(Total Lecture Hours: 45)

3. Books Recommended:

1	D. C. Montgomery. Design and analysis of experiments, John wiley & sons.
2	R. K. Roy. Design of experiments using the Taguchi approach: 16 steps to product and process improvement, John Wiley & Sons, 2001.
3	K. Hinkelmann, O. Kempthorne. Design and analysis of experiments, volume 1: Introduction to experimental design, Vol. 1, John Wiley & Sons.
4	A. Dean, D. Voss. Design and analysis of experiments, Springer.
5	J. Antony. Design of Experiments for Engineers and Scientists, 2nd Edition, Elsevier Inc., 2014.

MECC114	:	INSTRUMENTATION AND EXPERIMENTAL METHODS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to

CO1	Understand of experimental analysis and Instrumentation related to measurement systems.
CO2	Analyse and fit the experimental data. Different kind of errors coming in data will also be analysed.
CO3	Explain error and uncertainty in physical measurements.
CO4	Determine the mathematical model of measurement systems and response characteristics.
CO5	Discuss the concepts of Data acquisition signal process analysis.
CO6	Explain principles, theory and applications of various sensors and transducers of flow and temperature measurements.

2. Syllabus:

Significance of Measurement and Instrumentations	**(05 Hours)**
Introduction, generalized configuration and functional stages of measuring systems, the transducer and its environment, an overview, sensing process and physical laws, Types of measurement problems. Transducer classification and their modelling, characteristics of instruments, design and selection of components of a measuring system.	
Dynamic Response of Instruments	**(05 Hours)**
Mathematical model of a measuring system, response of general form of instruments to various test inputs; time domain and frequency domain analysis Elementary transfer functions, Bode plots of general transfer functions.	
Errors in Measurement and Uncertainty in measurements	**(06 Hours)**
Errors in instruments, Causes and types of experimental errors, Analysis of experimental data and determination of overall uncertainties in experimental investigation, Uncertainties in measurement of measurable parameters like pressure, temperature, flow etc. under various conditions, Estimation for design and selection for alternative test methods.	
Transducers	**(08 Hours)**
Developments in sensors, detectors and transducer technology, displacement transducers; force, torque and motion sensors, piezoelectric transducers, capacity type transducers, Strain gauge transducers, Accelerometers, pressure transducers based on elastic effect of volume and connecting tubing. Transducers for Position, speed, vibration, sound, humidity, and moisture measurement, Hall effect Transducer.	

Data Acquisition and Signal Processing	(05 Hours)
Systems for data acquisition and processing modules and computerized data system digitization rate, time and frequency domain representation of signals, and Nyquist criterion a brief description of elements of mechatronics modular approach to mechatronics and engineering design.	
Advanced Flow Measurements Basic flow meters, magnetic, ultrasonic flow meters, Flow visualization, shadowgraph, Schlieren and interferometric techniques, Pitot static tubes; hot wire anemometers, flow measuring problems, Laser Doppler velocity meter, flow measurements using coriolis effect.	**(08 Hours)**
Systems for data acquisition and processing modules and computerized data system digitization rate, time and frequency domain representation of signals, and Nyquist criterion a brief description of elements of mechatronics modular approach to mechatronics and engineering design.	
Temperature Measurements	**(08 Hours)**
Modes of heat transfer, laws of conduction, convection and radiation, Temperature scales, classification of Temperature Sensors, Overview of Temperature Sensor Material, Expansion thermometers, filled system thermometers Thermoelectric sensors, electric resistance sensors; thermistors, Electrical temperature instruments, thermocouples, RTD, and thermistors, Pyrometers, IR temperature detectors, radiations pyrometers, Temperature measuring problems in flowing fluids, dynamic compensation.	

(Total Lecture Hours: 45)

3. Books Recommended:

1.	E. O. Doeblin. Measurements System Application and Design, 5th Edition, McGraw Hill, 2004.
2.	J. P. Holman. Experimental Methods for Engineers, 8th Edition. New York: McGraw-Hill, 2012.
3.	T. G. Beckwith, R. D. Marangoni, J. H. Lienhard. Mechanical Measurements, 6th Edition, Prentice Hall of India, 2006.
4.	A. K. Gosh. Introduction to Measurements and Instrumentation, 4th Edition, PHL Learning Private limited, 2012.
5.	P. E. Donald. Industrial Instrumentation, CBS publishers, 2004.

MECC116	:	SMART MATERIALS AND MANUFACTURING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to

CO1	Understand the ideas about intelligent and smart materials.
CO2	Study the applications of electro-rheological fluids and Piezoelectric materials.
CO3	Apply the concept and use of shape memory materials and fibre optics in the modern applications.
CO4	Design the vibration absorption systems.
CO5	Evaluate the modelling of shells, beams and plates.
CO6	Elaborate the outcomes related to the smart structure for a specific application.

2. Syllabus:

Smart Materials and Structural Systems	**(06 Hours)**
Introduction to Smart Materials and Structures, Actuator materials, sensing technologies, micro-sensors, intelligent systems, hybrid smart materials, passive sensory smart structures, reactive actuator-based smart structures, active sensing and reactive smart structures, smart skins.	
Intelligent Materials	**(05 Hours)**
Primitive functions of intelligent materials, intelligence inherent in materials, materials intelligently harmonizing with humanity, intelligent biological materials.	
Electro–Rheological Fluids	**(05 Hours)**
Suspensions and electro, rheological fluids; the electro-rheological phenomenon, charge migration mechanism for the dispersed phase, electro rheological fluid actuators	
Piezoelectric Materials	**(04 Hours)**
Background, Piezoelectricity, industrial piezoelectric materials, smart materials featuring piezoelectric elements	
Shape Memory Materials	**(04 Hours)**
Background on shape memory alloys, applications of shape memory alloys, Continuum applications: structures and machine systems, Discrete applications, impediments to applications of shape memory alloys, shape memory plastics.	
Fiber Optics	**(05 Hours)**
Overview, light propagation in an optical fiber, embedding optical fibers in fibrous polymeric thermo-sets, fiber optic strain sensors.	
The Piezoelectric Vibrations Absorber Systems	**(08 Hours)**

Introduction, single mode absorber, theory, design solution, extension including viscous modal damping, the electromechanical coupling coefficient, inductance, experimental results, multimode absorber, derivation of transfer function, design solution, self-tuning absorber, performance function, control scheme.	
Modelling of Shells, Plates and Beams	**(08 Hours)**
Derivation of the basic shell equations, equation of motion, equations for specific geometries and cylindrical shell, Plate equations and beam equations.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	M. V. Gandhi, B. D. Thompson, B. S. Thompson. Smart Materials and Structures, Springer Netherlands, 1992.
2	A. V. Srinivasan, D. Michael McFarland, Smart Structures: Analysis and Design, Cambridge, University Press, 2009.
3	P. L. Reece. Smart Materials and Structures: New Research, Nova Science Publishers, 2007.
4	A. Preumont. Vibration Control of Active Structures: An Introduction, Springer, 2011.
5	F. Y. Cheng, H. Jiang, K. Lou. Smart Structures: Innovative Systems for Seismic Response Control, CRC Press, 2008.

MECC118	:	COMPUTER AIDED TOOL DESIGN	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to

CO1	Define properties of tool material and nomenclatures related to press tools and classifying different cutting tools
CO2	Explain different types of locaters, clams, bushes, gauges and moulds for designing jigs fixtures for and inspection aids for engineering components
CO3	Design jig, fixtures, and moulding dies of a given engineering component and use of computer for creating model
CO4	Evaluate the dimension of press tool components for a given configuration /types of shearing die
CO5	Apply thumb rules and empirical formulas to solve problem related to shearing operation dies and punches and other cutting tools
CO6	Analyse a different scheme of strip layouts for maximizing stock utilisation and use of computer design for a given case for examining feasibility of design

2. Syllabus:

Tool Design Methods	**(07 Hours)**
Introduction, Design procedure, Statement of the problem, Needs Analysis – Tentative design solutions, finished design, Drafting and design techniques in tooling drawings, Punch and die Manufacturing Techniques.	
Tooling Materials	**(07 Hours)**
Introduction, Properties of tool materials, Metal cutting tools, Single-point cutting tools, milling cutters, Drills and Drilling, Reamer classification, Taps, tap classification, The selection of carbide cutting tools, Determining the insert thickness for carbide tools, Various heat treatments.	
Gages and Gage Design	**(05 Hours)**
Introduction, Fixed Gages, Gage Tolerances, the selection of material for Gages, Indicating Gages, and Automatic gages.	
Design of Drill Jigs	**(10 Hours)**
Principles of location, locating methods and devices, Principles of clamping, Drill jigs, Chip formation in drilling, General considerations in the design of drill jigs, Drill bushings, Methods of construction, Drill jigs and modern manufacturing, Computer aided Jig design. **Design of Fixtures**	

Introduction, Fixtures and economics, Types of Fixtures, Vice Fixtures, Milling Fixtures, Boring Fixtures, Broaching Fixtures, Lathe Fixtures, Grinding Fixtures, Types of Die construction, Computer aided Fixture Design,

Design of Press Tools	**(08 Hours)**
Die-design fundamentals, Blanking and Piercing die construction, Pilots, Strippers and pressure pads, Presswork materials, Strip layout, Short -run tooling for Piercing, Bending dies, Forming dies, Drawing operations.	
Design of Moulding Dies	**(08 Hours)**
Introduction to Injection moulding process, Parting line selection, Requirement of Air vents, Ejection system, Computer aided die design for injection moulding, Compression molding.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	C. Donaldson, H. L. George, V. C. Goold. Tool Design, Tata McGraw Hill Publishing Company Ltd., 36th Reprint 2006.
2	P. H. Joshi. Tooling Data, Wheeler Publishing, 2000.
3	P. C. Sharma. Machine Tool and Tool Design, S Chand Company. 2004.
4	J.Y.H. Fuh. Computer aided Injection mold design and manufacture, CRC Press 2018.
5	J. R. Paquin, R. E. Crowley. Die design fundamentals, Ind. Press Inc., New York, 1987.

MECC120	:	QUALITY ENGINEERIN AND MANAGEMENT	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to

CO1	Explain the different concepts of quality, system reliability & maintenance and its application to the design and manufacturing activities.
CO2	Understand and Apply statistical concepts and techniques for designing of products and process controls.
CO3	Describe and apply reliability analysis concepts to selected applications.
CO4	Describe and Apply the two level factor factorial design, general factorial design and surface response method for experimental design.
CO5	Formulate, analyze, design and synthesize open-ended quality engineering problems using the various statistical process control tools and quality management tool.
CO6	Select and apply newer concepts and initiatives for quality improvement.

2. Syllabus:

Introduction	**(02 Hours)**
Introduction to quality control and the quality system, some philosophies and their impact on quality, Cost of quality, Quality audit.	
Statistical Quality Control	**(14 Hours)**
Statistical Concepts and Data analysis: Fundamentals of statistical concepts and techniques in quality control and improvement, Data analysis and sampling; Control Charts: Statistical Process Control using control charts, Control charts for attributes and variables. Process capability analysis: Concepts and procedures of Process capability. Acceptance Sampling: Acceptance sampling for attributes and variables.	
Reliability Analysis	**(03 Hours)**
Reliability: Failure rate analysis, mean failure rate, mean time to failure, mean time between failure, Graphical representation of Fd, Z and R. Generalization in graphical form, integral form, Hazard models, systems reliability, availability, maintenance, overall equipment effectiveness, Total Productive Maintenance (TPM), Failure Mode and Effect Analysis (FMEA).	
Experimental Design	**(08 Hours)**
Experimental Design: Fundamentals of experimental Design, Single, Multi factor and 2k factor experiments, Two level fractional factorial design, Response surface method. Quality loss function. Taguchi method: Taguchi method, Design of experiments using orthogonal array, Data analysis from Taguchi and Multi level factor design.	
New Quality Concepts and Initiatives	**(12 Hours)**

New Quality Concepts and initiatives: Total Quality Management (TQM) and its techniques, New Seven Management Tools, and Industrial Case studies on Costs of Quality, Five S, kaizen, Quality Circles, Quality Function Deployment (QFD), Poka Yoke, Total Productive Maintenance (TPM), Lean Manufacturing, Six Sigma, Lean Six Sigma, etc. Quality Management through Software.	
Quality Standards	**(03 Hours)**
Quality Standards and Business Excellence Models: Quality System Standards, ISO 9000, ISO 14000, various Quality Awards and case studies.	
World Class Manufacturing	**(03 Hours)**
Manufacturing Excellence World Class Manufacturing (WCM) – Model and elements of WCM.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	A. Mitra. Fundamentals of Quality Control and Improvement, 2nd Ed., Prentice Hall of India, 2011
2	K. Krishnaiah, P. Shahabudeen. Applied Design of Experiments and Taguchi Methods, Prentice Hall of India, 2012.
3	Dale H. Besterfield, Carol Besterfield-Michna, Mary Besterfield-Sacre, Glen H. Besterfield, Hemant Urdhwareshe, Rashmi Urdhwareshe, Total Quality Management, , Pearson Education, 2012.
4	G. W. Cobb. Introduction to Design and Analysis of Experiments, John Wiley & Sons, 2015.
5	D. C. Montogomery. Introduction to Statistical Quality Control, John Wiley & Sons, 8th Edition, 2013.

MECC122	:	OPTIMIZATION TECHNIQUES	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to

CO1	Understand the concept of optimization, related terms and formulate mathematical models for practical problems based on the information provided.
CO2	Use linear programming to solve real life linear programming problems
CO3	Solve transportation and transhipment problems, travelling salesman problem and integer programming
CO4	Determine solutions that will be deployed in real world situations after conducting sensitivity and post optimality analysis
CO5	Apply classical methods to solve nonlinear programming problems
CO6	Apply evolutionary algorithms to solve complex engineering problems where classical methods are not suitable.

2. Syllabus:

Introduction	**(05 Hours)**
Introduction to optimization, linear programming, formulation, graphical method, simplex method and special cases.	
Sensitivity and post optimality analysis	**(08 Hours)**
Sensitivity analysis and post optimality analysis, changes in resources and objective function, changes affect feasibility and optimality, duality, dual simplex algorithm, generalize simplex algorithm.	
Special types of linear programming problems	**(06 Hours)**
Transportation problems, Transshipment problems, Travelling salesman problems, Integer programming.	
Introduction to MATLAB and solving linear and nonlinear problems using MATLAB	**(07 Hours)**
Introduction to MALAB, creating and manipulating vectors and matrix, user defined function, special built-in function to create special vectors and matrices, symbolic math, built-in function to solve linear programming problems.	
Nonlinear programming problems	**(05 Hours)**
Nonlinear Programming problems: Graphical method, convex function and convex region, necessary and sufficient conditions, Lagrangian method, Karush-Kuhn-Tucker (KKT) conditions, solving nonlinear problems using MATLAB.	
Evolutionary Algorithm	**(14 Hours)**

Introduction to evolutionary algorithm, introduction to multi-objective optimization, genetic algorithms, differential evolution algorithm, Particle swarm optimization, tabu search, simulated Annealing technique, solving real life engineering problems using given programming software.

(Total Lecture Hours: 45)

3. Books Recommended:

1	F. S. Hillier, G. J. Lieberman, B. Nag, P. Basu. Introduction to operations research, Tata McGraw-Hill Education, 2017.
2	H. A. Taha. Operations research: an introduction, Pearson Education India, 2017.
3	S. S. Rao. Engineering optimization: theory and practice, John Wiley & Sons, 2019.
4	A. Vasuki. Nature-Inspired Optimization Algorithms, CRC Press, 2020.
5	D. E. Goldberg. Genetic algorithms: in search, optimization and machine learning, Pearson Education India, 2006.

MECC124	:	THEORY OF ELASTICITY AND PLASTICITY	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to

CO1	Explain the concept of equilibrium, torsion and bending of bars using theory of elasticity.
CO2	Apply plastic flow theory to predict the material deformation or fracture of selected mechanical component
CO3	Compute the numerical problems using flow rule, plastic work increment, work hardening and tensile instability
CO4	Develop analytical modelling and skills of engineering application related to plastic deformation
CO5	Explain the theory of local necking under uniaxial and biaxial tension in sheet metal forming applications
CO6	Apply plasticity concepts to analyse the stamping, bending and deep drawing process in metal strips

2. Syllabus:

Theory of Elasticity	**(10 Hours)**
Plane stress and plane strain, Stress and strain at a point. Equilibrium and compatibility equations. Two dimensional problems in rectangular and polar co –ordinates, Mohr's Circle of Stress in Two dimensions, three dimensional problems, Mohr's Circle of Stress in Three dimensions, Torsion and bending of bars.	
Principles of Plastic Flow Theory	**(12 Hours)**
Stress tensor, Hydrostatic and Deviator component of Stress, Plastic Stress & Strain relationship & Condition of initiation of plastic deformation, Failure Criterion, Plastic work increment, Plastic Anisotropy, Two-dimensional plastic flow theory- Slip line field theory, Introduction of large strains, Strain or work hardening, Experimental strain analysis.	
Tensile Instability	**(11 Hours)**
Introduction, Uniaxial tension of a perfect & an imperfect strip, Uniaxial tension of a rate dependent material, necking in continuous bar, sheets, necking in biaxial tension, Effect of strain hardening, Effect of rate sensitivity, Ductile fracture & reduction of area, Determination of Forming Limit Strains for an Anisotropic material by Neck of growth. Methods for testing material properties.	
Stamping, Bending and Deep Drawing Analysis	**(12 Hours)**
Two-dimensional stamping model, Stretch and draw ratio in stamping, three-dimensional stamping model, bending without tension, bending in Vee-die, Spring back, bending of small	

radius, Deep drawing of a sheet, Cup height, drawing with flange, wall ironing of deep drawn cup.

(Total Lecture Hours: 45)

3. <u>Books Recommended:</u>

1	E. G. Thomsen, C. T. Yang, S. Kobayashi. Mechanics of Plastic Deformation in Metal Processing, The MacMilan Co, 1965.
2	E. M. Mielnik. Metal Working Science & Engineering, 1st Edition, McGraw - Hill, Inc., New York, 1991.
3	Z. Marciniak, J. L. Dancan, S. J. Hu. The Mechanics of Sheet Metal Forming, Butterworth-Heinemann, 2002.
4	S. P. Timoshenko, J. Goodier. Theory of Elasticity, McGraw Hill, 1975.
5	V. Molotnikov, A. Molotnikov. Theory of Elasticity and Plasticity: A Textbook of Solid Body Mechanics, Springer, 2021

MECC126	:	INDUSTRIAL TRIBOLOGY	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to

CO1	Understand and explain different laws of friction and topology of surfaces.
CO2	Differentiate between the types of lubricants, properties and its respective application area.
CO3	Appreciate the various modes of wear and the wear-mechanism maps.
CO4	Understand behaviour of bearing in different lubrication regimes and able to develop mathematical model.
CO5	Select the type of bearing for any given required engineering use and determine the load carrying capacity and other related parameters.
CO6	Decide on the tribological measurement techniques based on performance of machine components.

2. Syllabus:

Introduction to the Concept of Tribo-Design	**(04 Hours)**
Specific principles of tribo-design, tribological problems in machine elements.	
Basic Principles of Tribology	**(08 Hours)**
Sliding friction, relative motion in bodies, friction due to adhesion, deformation, energy dissipation during friction, types of wear and their mechanisms, wear in lubricated contacts and film lubrication.	
Friction, Lubrication and Wear in Lower Kinematic Pairs	**(10 Hours)**
Concept of friction angle, friction in screws with a square and triangular threads, plate, cone and centrifugal clutches, drives utilizing friction force, frictional aspects of brake design and tribo-design aspects of mechanical seals.	
Friction, Lubrication and Wear in Higher Kinematic Pairs	**(05 Hours)**
Loads acting on contact area, traction in contact zone, rolling friction and cam-follower systems.	
Sliding-Element Bearings	**(05 Hours)**
Derivation of Reynolds equation, hydrostatic and thrust bearings, journal bearings, gas bearings, steady-state analysis of fluid-film bearings, modern developments in journal bearing design, selection and design of thrust bearings.	
Rolling-Contact Bearings	**(06 Hours)**

Analysis of friction in rolling contact bearings, deformations and kinematics of rolling element bearings, lubrication analysis of rolling contact bearings.	
Lubrication and Efficiency of Involute Gears	**(07 Hours)**
Generalities of gear design, lubrication regimes, gear failure due to scuffing, gear pitting, design aspects of gear lubrication and efficiency of gears.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	D. Dowson, C.M. Taylor, M. Godet, D. Berthe. Tribological Design of Machine Elements, 1st Edition, Elsevier Science, 1989.
2	G. Stachowiak, A. Batchelor. Engineering Tribology, 3rd Edition, Elsevier Science, 2014.
3	A. Harnoy. Bearing Design in Machinery: Engineering Tribology and Lubrication, CRC Press, 2002.
4	S. Wen, P. Huang. Principles of Tribology, 2nd Edition, Wiley Publication, (ISBN: 978-1-119-21490-8), 2017.
5	R. Gohar, H. Rahnejat. Fundamentals of Tribology, 3rd Edition, World Scientific Publishing Company, 2018.

MECC128	:	DESIGN AND ANALYSIS OF COMPOSITE STRUCTURES	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Understand the different types of composite materials.
CO2	Analyse the macro mechanical behaviour of lamina.
CO3	Analyse the micro mechanical behaviour of lamina.
CO4	Analyze the macro mechanical behaviour of laminate.
CO5	Evaluate the bending, buckling and vibration of laminated plate.
CO6	Understand the design requirement of composite materials.

2. Syllabus:

Introduction	**(06 Hours)**
Classification and characteristics of composite materials, Mechanical behaviour of composite materials, Terminology of laminated composite materials, Manufacture of laminated composite materials, Applications of composite materials.	
Macro-Mechanical Behaviour of a Lamina	**(08 Hours)**
Stress-strain relationship for anisotropic materials, Stiffness, compliances and engineering constants for orthotropic materials, Relationship on engineering constants, Stress-strain relationship for plane stress in an orthotropic material, Strength of an orthotropic lamina	
Micro-Mechanical Behaviour of a Lamina	**(06 Hours)**
Mechanics of materials approach to stiffness, Elasticity approach to stiffness, Mechanics of materials approaches to strength.	
Macro-Mechanics Behaviour of a Laminate	**(07 Hours)**
Classical laminate theory, Special cases of laminate stiffness,Theoretical versus measured laminate stiffness, Strength of laminates, Interlaminar stresses.	
Bending, Buckling and Vibration of Laminated Plates	**(10 Hours)**
Governing equations for bending, buckling and vibration of laminated plate, Deflection of simply supported laminated plates under distributed transverse load, Buckling of laminated plate, Vibration of laminated plate.	
Introduction to Design of Composite Structures	**(08 Hours)**
Introduction, Introduction to structural design, Material Selection, Configuration Selection, Laminate joints, Design requirements and design failure criterion.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	K.K. Autar. Mechanics of composite materials, 2nd Edition, CRC Press, 2006.
2	R.M. Jones. Mechanics of composite materials, 2nd Edition, Taylor and Fransis, 2018.
3	M.M. Kaminski. Computational mechanics of composite materials, Springer, 2005.
4	B.D. Agarwal. Analysis and Performance of Fiber Composites, 3rd Edition, John Wiley & Sons, 2006.
5	R.F. Gibson, Principles of Composite Material Mechanics, 4th Edition, CRC Press, 2016

MECC130	:	SURFACE ENGINEERING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to

CO1	Decide the surface preparation methods suitable for different substrate materials.
CO2	Demonstrate the ability to use the core concepts of engineering application in material degradation by corrosion, wear and its prevention.
CO3	Elaborate role of surface modifications to achieve several technological properties.
CO4	Explain importance of specific coating technique ,characterization & its applications on specific engineering components.
CO5	Select surface engineering technique for specific wear mechanisms and corrosion control.
CO6	Propose suitable surface engineering technique to control material degradation.

2. Syllabus:

Introduction	**(04 Hours)**
Surface engineering: Introduction to surface engineering, Scope of surface engineering for different engineering materials, Surface Preparation methods such as Chemical, Electrochemical, Mechanical: Sand Blasting, Shot peening, Shot blasting, Hydro-blasting, Vapor Phase Degreasing etc., Coatings: Classification, Properties and applications of Various Coating.	
Wear	**(06 Hours)**
Adhesive wear, Abrasive and erosive wear, Wear induced by mechanical fatigue of the worn surface, melting wear, fretting wear and diffusive wear, Analytical models of wear, Wear resistant materials, Fatigue, fracture and creep.	
Corrosion	**(06 Hours)**
Corrosion of metals in aqueous media: Electrochemistry and aqueous corrosion, Electrochemical corrosion of machinery and structures, Corrosion inhibitors, Materials factors in aqueous corrosion. Oxidative reactions of metals with oxygen, sulphur and other halogens.	
Discrete Coatings	**(06 Hours)**
Introduction, Coatings of organic compounds, Electrochemical coatings, Plasma and thermal spraying, plasma-transferred arc the D gun, Vacuum-based coating methods, Friction surfacing, weld overlays and explosive bonding, Advanced coating techniques.	
Integral Coatings and Modified Surface Layers	**(08 Hours)**
Introduction, Thermally or mechanically modified surface layers: Induction hardening, Laser and electron beam surface hardening, Shot-peening, Thermochemical methods of coating: Galvanization and hot-dipping, Carburizing, carbonitriding, nitriding, nitrocarburizing & boronizing, Advanced surface modification technologies: Plasma nitriding and plasma carburization, Surface alloying by laser and electron beam, Ion implantation.	

Characterization of Surface Coatings	(07 Hours)
Introduction, Measurement of surface roughness and coating thickness, Hardness and microhardness analysis, Adhesivity testing, Microstructural evaluation, Chemical analysis, Residual stress analysis, Corrosion testing.	
Control of Materials Degradation	**(08 Hours)**
Introduction, Methodology of analysing materials degradation, Selection of optimal surface engineering technology, Control of wear by surface engineering, Principles of coating selection for wear resistance, Selection of specific surface engineering techniques for specific wear mechanisms, Control of corrosion by surface engineering, Control of fatigue and fracture by surface engineering	

(Total Lecture Hours: 45)

3. Books Recommended:

1	T. Burakowski, T. Wierzchon. Surface engineering of metals, CRC Press, 2020.
2	A. W. Batchelor, L. N. Lam, M. Chandrasekaran. Materials degradation and its control by surface engineering, 3rd Edition, Imperial college press, 2011.
3	L. I. Tushinsky, I. Kovensky, A. Plokhov, V. Sindeyev, P. Reshedko. Coated Metal: Structure and Properties of Metal-Coating Compositions, Springer, Germany, 2002.
4	M. Ohring. Materials Science of Thin Films, 2nd Edition, Academic Press, 2002.
5	L. I. Tushinsky, I. Kovensky, A. Plokhov, V. Sindeyev, P. Reshedko. Materials Degradation and Its Control by Surface Engineering, 3Ed Hardcover – Illustrated, February 2011.

MECC172	**:**	**EXTENDED FINITE ELEMENT METHODS**	**L**	**T**	**P**	**Credits**
			3	**0**	**0**	**03**

1. Course Outcomes (COs):

At the end of the course the students will be able to

CO1	Explain the principals of XFEM.
CO2	Analyze different modes of fracture.
CO3	Utilize enrichment functions to solve simple fracture problems by XFEM.
CO4	Evaluate stress intensity factor for isotropic and orthotropic materials by XFEM.
CO5	Evaluate the problems on Cohesive Cracks.
CO6	Solve XFEM based static and dynamic fracture problems.

2. Syllabus:

Introduction	**(08 Hours)**
Structures, discontinuities in the materials, fracture mechanics, comparison between FEM and XFEM, general aspects of XFEM, Partition of unity, enrichment functions, local and non-local models, discrete cracked element, singular elements, enriched elements, Basics of elasticity, LEFEM, strong and weak discontinuities, cracks modeling, XFEM application.	
XFEM for Isotropic Problems	**(08 Hours)**
Basics of FEM, basics of fracture mechanics, partition of unity, enrichment, isotropic XFEM, modeling of strong and weak discontinuities, XFEM approximation, signed distance function, modeling of strong and weak discontinuous fields, modeling of crack, XFEM discretization and integration, tracking moving boundaries, level set method, numerical simulations: A tensile plate with a central crack, single and double edge cracks, edge and center crack in finite and infinite plate.	
XFEM for Orthotropic Problems	**(09 Hours)**
Anisotropic elasticity, elasticity solution, anisotropic stress functions, orthotropic mixed mode problems, energy release rate and stress intensity factor for anisotropic materials, analytical solutions for near crack tip, near crack tip displacement field, XFEM discritization and SIF calculations, numerical simulations: Plate with a crack parallel to material axis of orthotropy, orthotropic and isotropic materials with crack subjected to tensile tractions.	
XFEM for Cohesive Cracks	**(10 Hours)**
Cohesive cracks, Numerical models for cohesive cracks, Crack propagation criteria, Griffith criterion for cohesive crack, Cohesive crack model, XFEM for cohesive cracks (enrichment functions, governing equation and XFEM discritization), numerical simulations: mixed mode bending beam, four point bending beam and double cantilever beam.	
Static and Dynamic Fracture Analysis	**(10 Hours)**

Analytical Solutions for Near Crack Tip, Mixed Mode Fracture, SIF Calculation by Interaction Integral, Anisotropic XFEM, Analytical Solutions for Near crack tips in dynamic states, analytical solution for near crack tip of a Propagating crack Material, dynamic stress intensity factor, numerical simulations: plate with stationary centre crack, mode I plate with edge crack, mixed mode edge crack in composite plate, composite plate with crack under impulsive loading.

(Total Lecture Hours: 45)

3. Books Recommended:

1	S. Mohammadi. Extended finite element method, 1st edition, Blackwell, 2007.
2	XFEM fracture mechanics of composites, 1st edition, A John Wiley & Sons, Ltd., Publication 2012.
3	P Kumar. Elements of fracture mechanics, Tata McGraw Hill, New Delhi, 2017.
4	Anderson. Fracture Mechanics-Fundamental and Application, T. L. CRC press1998.
5	R. B. Charlie, A. Chaudhary. Failure Analysis of Engineering Materials, McGraw Hill, New York, 2001.

MECC174	:	COMPUTATIONAL FLUID DYNAMICS TECHNIQUE	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to

CO1	Develop mathematical model for fluid flow through turbomachine passage.
CO2	Discretize the fundamental equations of flow and other transport processes.
CO3	Apply finite volume method for numerical modeling of flow.
CO4	Solve flow problems using semi-explicit and semi-implicit algorithms.
CO5	Generate mesh for flow domain in complex turbomachinery geometry.
CO6	Solve Navier-Stokes equations for flow through complex turbomachine passages.

2. Syllabus:

Review of Governing Equations Fluid Flo w and Heat Transfer	**(07 Hours)**
Conservation of Mass, Newton's Second Law of Motion, Expanded Forms of Navier stokes equations, Conservation of Energy Principle, Special Forms of the Navier Stokes Equations, Classification of Second order Partial Differential Equation s, Initial and Boundary Conditions, Governing Equations in Generalized Coordinates.	
Finite Difference, Discretization, Consistency, Stability and Fundamental of Fluid Flow Modeling	**(09 Hours)**
Elementary Finite Difference Quotients, Basic Aspects of Finite Difference Equations, Errors and Stability Analysis, Some Nontrivial Problems with Discretized Equations, Applications to Heat Conduction and Convection.	
Solution of Viscous Incompressible Flows by Stream Function -Vorticity Formulation	**(09 Hours)**
Two-Dimensional Incompressible Viscous Flow, Incorporation of Upwind Scheme, Estimation of Discretization Error, Application to Curvilinear Geometries, Derivation of Surface Pressure and Drag.	
Solution of Navier-Stokes Equations for Incompressible Flows Using MAC and SIMPLE Algorithms	**(10 Hours)**
Staggered Grid, Solution of the Unsteady Navier -Stokes Equations, Solutions of Energy Equation, Formulation of the Flow Problems, SIMPLE Algorithm.	
Introduction to FVM:	**(10 Hours)**
Integral Approach, discretization & Higher order scheme, Finite Volume Solution of Unsteady Advection, Diffusion Problems with Source Term.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	D. A. Anderson, J. C. Tannehill, R. H. Pletcher. Computational Fluid Mechanics and Heat Transfer, Hemisphere Publishing Corporation, New York, U.S.A, 1984.
2	K. Murlidhar, T. Sunderarajan. Computational Fluid Flow and Heat Transfer, Narosa Publishing House, New Delhi, 2003.
3	J. D. Anderson Jr. Computational Fluid Dynamics, McGraw Hill, Inc. New York, 1996.
4	S. V. Ankar. Numerical Heat Transfer and Flow, Hemisphere Publ., Corporation, 1985.
5	H. K. Versteag, W. Malalsekara. An Introduction to Computational Fluid Dynamics, Pearson, 2008

			L	T	P	Credits
MECC106	**:**	**SOFTWARE PRACTICE - II**	**0**	**0**	**4**	**02**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Develop program using various commands.
CO2	Develop program with instructive computation.
CO3	Apply programming language to solve engineering problems.
CO4	Generate code for solving engineering problems using differential equations.
CO5	Formulate FEA codes for 1D and 2D problems.
CO6	Formulate FEA codes for thermal problems.

Exercises:

1. Exploring programming languages such as MATLAB / Python / Scilab, etc.
2. Write code for 2^{nd} order differential equation for given problems.
3. Write FEA code for solving a given problem of 1D spring and linear bar element.
4. Write FEA code for solving a given problem of 2D truss structure.
5. Write FEA code for solving a given problem of Plane stress and Plane strain
6. Write FEA code for solving a given problem of thermal analysis.

DEPARTMENT OF
MECHANICAL ENGINEERING

M.TECH. (MANUFACTURING ENGINEERING)

SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY
Ichchhanath, Surat-395007, Gujarat, India
www.svnit.ac.in

MISSION & VISION STATEMENT OF INSTITUTE

Vision Statement

To be one of the leading technical institutes disseminating globally acceptable education, effective industrial training and relevant research output

Mission Statement

To be a globally accepted centre of excellence in technical education catalysing absorption, innovation, diffusion and transfer of high technologies resulting in enhanced quality for all stakeholders

MISSION & VISION STATEMENT OF THE DEPARTMENT

Vision Statement

Department of Mechanical Engineering, Sardar Vallabhbhai National Institute of Technology, Surat perceives to be globally accepted centre of quality technical education based on innovation and academic excellence.

Mission Statement

Department of Mechanical Engineering, Sardar Vallabhbhai National Institute of Technology, Surat strives to disseminate technical knowledge to its under graduate students, post graduate students and research scholars to meet intellectual, ethical and career challenges for sustainable growth of humanity, nation and global community.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

The Program of M. Tech. (Manufacturing Engineering) will produce graduates who will be able to:

PEO1	processes and systems using appropriate methods and tools
PEO2	Apply manufacturing engineering education to address technical and societal problems with creativity, imagination, confidence and ethics
PEO3	Utilize communication skills in oral, written, visual and graphic modes within interpersonal, team, and group environments.
PEO4	Retain intellectual curiosity for lifelong learning and flexible response to the rapidly evolving manufacturing challenges of the 21st century

Program Articulation Matrix

Department Mission	**Mapping of PEO**			
	PEO1	PEO2	PEO3	PEO4
Department of Mechanical Engineering, Sardar Vallabhbhai National Institute of Technology, Surat strives to disseminate technical knowledge to its under graduate students, post graduate students and research scholars to meet intellectual, ethical and career challenges for sustainable growth of humanity, nation and global community.	3	3	1	1

PROGRAM OUTCOMES (POs)

Proposed Program Outcomes (POs):

The graduates of M. Tech. (Manufacturing Engineering) will demonstrate an ability to:

PO1	Carry out independent research /investigation and development work to solve practical problems
PO2	Write and express a substantial technical report/document
PO3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PSO1	Design, analyse and develop parts using manufacturing process(es) and system(s) for innovative research and industrial application by following quality and safety standards.
PSO2	Impart solution(s) to industrial and societal problems for economic and sustainable benefits with high moral and professional ethics

COURSE STRUCTURE FOR

M. TECH. (MANUFACTURING ENGINEERING)

SEMESTER – I

Sr. No.	Code No.	Subject	L	T	P	Exam Scheme Theory Marks	Exam Scheme Tuto. Marks	Exam Scheme Pract. Marks	Credits
01	MEMF101	**Core 1** Advanced Machining Processes	3	0	2	100	-	50	4
02	MEMF103	**Core 2** Sheet Metal Forming	3	1	2	100	25	50	5
03	MEMF105	**Core 3** Operations, Planning & Control	3	1	0	100	25	-	4
04		**Core Elective 1**	3	0	0	100	-	-	3
	MEMF111	1. Advanced Welding Technology							
	MEMF113	2. Computer added production planning							
	MEMF115	3. Metal Cutting and Tool Design							
	MEMF117	4. CAD for Manufacturing							
	MEMF119	5. Manufacturing Metallurgy							
05		**Core Elective 2**	3	0	0	100	-	-	3
	MEMF121	1. Industrial Robotics							
	MEMF123	2. Advanced Metrology and Computer Aided Inspection							
	MEMF125	3. Failure Analysis							
	MEMF127	4. Optimization Techniques							
	MEMF129	5. Theory of Plasticity							
06	MEMF107	Laboratory Practice	0	0	4	-	-	100	2
	Total Credits								**21**
	MEMFV01 MEMFP01	Vocational Training/ Professional Experience (Optional) (Mandatory for exit)	0	0	10	-	-	-	5

SEMESTER – II

Sr. No.	Code No.	Subject	L	T	P	Exam Scheme Theory Marks	Exam Scheme Tuto. Marks	Exam Scheme Pract. Marks	Credits
01	MEMF102	**Core 4** Computer Integrated Manufacturing	3	1	2	100	25	50	5
02	MEMF104	**Core 5** Additive Manufacturing Processes	3	0	2	100	-	50	4
03		**Core Elective 3**	3	0	0	100	-	-	3
	MEMF110	1. Metal Casting							
	MEMF112	2. Finite Element Methods							
	MEMF114	3. Industrial Tribology							
	MEMF116	4. Automation in Manufacturing							
	MEMF118	5. Composite Design and Manufacturing							
04		**Core Elective 4**	3	0	0	100	-	-	3
	MEMF120	1. Surface Engineering							
	MEMF122	2. Quality Engineering and Management							
	MEMF124	3. Operations Research							
	MEMF126	4. Concurrent Engineering							
	MEMF128	5. Numerical Methods in Manufacturing							
05		**Institute Elective**	3	0	0	100	-	-	3
	MEMF130	1. Non-Destructive Testing							
	MEMF132	2. Intelligent Manufacturing Systems							
	MEMF134	3. Logistics and Supply Chain Management							
	MEMF136	4. Micro and Nano Manufacturing							
	MEMF138	5. Bio Inspired Materials							
	MEMF140	6. Design of Experiments							
06	MEMF106	**Mini Project**	0	0	4	-	-	100	2
	Total Credits								**20**
	MEMFV02 MEMFP02	Vocational Training/ Professional Experience (Optional) (Mandatory for exit)	0	0	10	-	-	-	5

SEMESTER – III

Sr. No.	Code No.	Subject	L	T	P	Exam Scheme			Credits
						Theory Marks	Tuto. Marks	Pract. Marks	
01		MOOC Course I*	3	0	0	-	-		3
02		MOOC Course II*	3	0	0				3
03	MEMF295	Dissertation Preliminaries	0	0	14	-	-	350$	14
	Total Credits								**20**

SEMESTER – IV

Sr. No.	Code No.	Subject	L	T	P	Exam Scheme			Credits
						Theory Marks	Tuto. Marks	Pract. Marks	
01	MEMF296	Dissertation	0	0	24	-	-	600$	20
	Total Credits								**20**

$ Internal 40% and external 60%
* Swayam/NPTEL

CREDIT MATRIX

Category	Credits to be earned				
	Sem- I	**Sem - II**	**Sem- III**	**Sem - IV**	**Total**
Core Courses	13	09	-	-	22
Elective Courses	06	09	-	-	15
Laboratory Practice	02	-	-	-	02
Mini Project		02			02
MOOC Course	-	-	06	-	06
Dissertation	-	-	14	20	34
Total Credits	**21**	**20**	**20**	**20**	**81**

MEMF101	:	ADVANCED MACHINING PROCESSES	L	T	P	Credits
			3	0	2	04

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the need, classification, working and applications of advanced machining processes
CO2	Derive model for MRR and deduce relationship with various process parameters
CO3	Explain and select finishing processes and express relationship between process parameters and responses
CO4	Describe the need and working of a micro machining process and distinguish it from macro machining processes
CO5	Examine the possibility of combining different process to develop hybrid processes for more efficient Machining process
CO6	Analyse the requirement of machining/finishing according to shape, material and size of product and select the best process among various alternatives

2. Syllabus:

Introduction: Advanced Machining Processes & Mechanical Energy Based Processes	**(08 Hours)**
Evolution, need, and classification of advanced machining processes. Mechanical Energy Based Processes: USM, AJM, WJM, AWJM processes – Working Principle, equipment, Material removal rate, Process and performance parameters, Applications, Operational characteristics; Limitations	
Thermal and Electrical Energy Based Processes	**(08 Hours)**
EDM, Working Principle, equipment details, Wire Electro-Discharge Machining (WEDM), electrode / Tool – Power and control Circuits-Tool Wear -Dielectric – Flushing, Material removal rate, Process, and performance parameters such as Surface finish and accuracy, Applications. LBM, EBM, IBM, PAM processes – Working Principle, equipment, Material removal rate, Process and performance parameters, Applications, Process Capabilities, Limitations.	
Chemical and Electro Chemical Energy based Processes	**(06 Hours)**
Working principle and details of Chemical Machining (CHM), Photo-Chemical Machining (PCM), and Electro Chemical Machining ECM) - Working Principle, equipment, Material removal rate, Process and performance parameters, Applications, Tool Design	
Advanced Finishing Processes	**(07 Hours)**
Abrasive Flow Machining (AFM), Magnetic Abrasive Finishing (MAF), Magneto Rheological Abrasive Finishing (MRAF) - Principle of working, equipment, Material removal rate, Process and performance parameters, Applications, Limitations.	
Micro Machining Processes	**(08 Hours)**

Miniaturization, scaling laws, Principle and working of micro turning, micro milling, micro EDM, micro USM, Laser micro machining, diamond turn machining	
Hybrid Machining Processes	**(08 Hours)**
Need, Classification: Assisted Hybrid Machining Processes, Laser Assisted Machining, Vibration Assisted Machining, Electro Stream Drilling (ESD), Electrochemical Deburring (ECDe), Electro Chemical Discharge Machining (ECDM)- Working Principle, equipment description, Material removal rate, Process and performance parameters, Applications	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Jain, V.K., Advanced Machining Processes. Allied publishers, 1st Edition, 2009
2	Pandey, P.C. and Shan, H.S., Modern machining processes. Tata McGraw-Hill Education, 2003
3	Mishra P. K., Nonconventional machining, Narosa publishing house, 2011
4	Jain V. K., Introduction to micro machining, Narosa publishing house, New Delhi, 1st Edition, 2010
5	Ghosh A. & Malik A. K. , Manufacturing Science, Affiliated East–West press Pvt. Ltd., 2002

List of Practicals:

1. To study the effect of process parameters on MRR and TWR during EDM process
2. To study the effect of welding parameters during ultrasonic welding of similar/dissimilar metals
3. To study single pass and multi pass wire EDM process to cut complex geometries
4. To study the kerf and surface finish during abrasive water jet machining process
5. To study the micro milling of metal/ non-metal part
6. To study the micro turning of Brass rod
7. To study the micro EDM process using different micro electrodes
8. To study the effectiveness of hybrid ECDM process
9. To study the EDM process improvement using tool actuation
10. To study and demonstrate laser engraving process

MEMF103	:	SHEET METAL FORMING	L	T	P	Credits
			3	1	2	05

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the sheet deformation processes and recognize load instability and tearing in sheet metal forming.
CO2	Apply the theory of plasticity and its application for analysing given sheet metal forming processes
CO3	Compute the stresses and forces during stamping and deep drawing process
CO4	Evaluate the punching forces using principles of punching and blanking process
CO5	Analyse principles, capabilities and applications of bending process and sheet hydro forming
CO6	Select suitable sheet metal forming process for given application

2. Syllabus:

Fundamentals of Metal Forming	**(04 Hours)**
Advantages of Metal Forming, cold and hot forming, various metal forming processes, Tensile Test - load–extension diagram, engineering stress–strain curve, true stress–strain curve, Anisotropy, Rate sensitivity, Effect of properties on forming	
Sheet Deformation Processes (Plane Stress)	**(10 Hours)**
Deformation in uniaxial tension, stress and strain ratios, theory of yielding in plain stress condition - Maximum shear stress, Hydrostatic stress, Tresca yield condition, Von Mises yield condition, Levy–Mises flow rule, Relation between the stress and strain ratios, Work of plastic deformation, Work hardening hypothesis, Effective stress and strain functions, Concept of Formability, formability limits and formability diagram. Factors affecting the forming limit curve.	
Load Instability and Tearing	**(09 Hours)**
Uniaxial tension of a perfect strip, Tension of an imperfect strip, Tensile instability in stretching continuous sheet - condition for local necking in uniaxial and biaxial tension.	
Analysis of Stamping and Deep Drawing Process	**(06 Hours)**
Two-dimensional model of stamping, stretch and draw ratios in a stamping, three-dimensional stamping model, Limiting drawing ratio and anisotropy, effect of strain-hardening and friction on drawing stress, redrawing and reverse redrawing of a cylindrical cup, wall ironing of deep- drawn cups, estimation of drawing force	
Analysis of Punching and Blanking Process	**(04 Hours)**
Mode of metal deformation and failure, deformation model and fracture analysis, determination of working force	

Analysis of Bending Process	(06 Hours)
Strain distribution in bending, bending without tension, bending of sheet in v-die, bending of different material behaviour like elastic perfect plastic sheet, strain hardening plastic sheet, etc. determination of work load, stock length and punch angle, springback and reverse bending, bending line construction	
Analysis of Sheet Hydroforming	**(06Hours)**
Free expansion of a cylinder by internal pressure, Forming a cylinder to a square section, Tube forming in a frictionless die, Tube forming with sticking friction (or very high friction), Constant thickness forming, Sequential hydroforming	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Hill R., "The Mathematical Theory of Plasticity", Oxford University Press, 2004
2	Hu S.J., Marciniak Z. and Duncan J.L., "Mechanics of Sheet Metal Forming", Butterworth- Heinemann, 2002
3	Timoshenko S. P., "Theory of Elasticity", McGraw Hill Education, 2017
4	Ghosh A. and Malik A., "Manufacturing Science", East-West Press Pvt Ltd., 2010.
5	Dally J. W. and Riley W. F., "Experimental Stress Analysis", McGraw-Hill Education, 1991

List of Practicals:

1. To Perform tensile test on different metal samples and plot the load-extension diagram
2. To Study the rate sensitivity of different metals by varying the strain rates during deformation.
3. To Study the temperature sensitivity of different metals by varying the temperature during deformation
4. Experiment with various metals to determine yielding using the Tresca and Von Mises yield criteria.
5. To Conduct formability tests on sheet metals
6. To Study local necking conditions in uniaxial and biaxial tension.
7. To Perform deep drawing experiments and measure the limiting drawing ratio and drawing force.
8. To Conduct punching and blanking experiments to observe deformation modes and failure mechanisms
9. To Perform bending tests on sheets using a V-die.
10. Experiment with free expansion of a cylindrical tube using internal pressure.

MEMF105	:	OPERATIONS PLANNING AND CONTROL	L	T	P	Credits
			3	1	0	04

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Identify the elements of operations management and various transformation processes to enhance productivity and competitiveness
CO2	Analyse and evaluate various facility alternatives and their capacity decisions, develop a balanced line of production & scheduling techniques in operation environments
CO3	Plan suitable materials handling principles and Supply Chain practices in the operations.
CO4	Compute the inventory based on selected model for selected case
CO5	Develop aggregate MRP and ERP in operation environments.
CO6	Integrate Operation planning with supply chain for overall productivity rise

2. Syllabus:

Operations Planning & Control	**(04 Hours)**
Operations and Productivity, Operation strategy in a Global Environment	
Forecasting	**(04 Hours)**
Elements and steps in forecasting, Types of forecasting, Demand forecasting using qualitative and quantitative methods, Errors in forecasting	
Capacity Planning and Constraint Management	**(04 Hours)**
Process Strategies, Definition and Measurement of capacity, Adjusting capacity, Quantitative methods for capacity planning decision	
Layout and Location Strategy	**(05 Hours)**
Types of layout, Design of Layout, Factors affecting location decision, Mathematical model for facility location and layout	
Supply Chain	**(05 Hours)**
The Supply Chain’s Strategic Importance Sourcing Strategies, Supply Chain Risk Managing the Integrated Supply Chain Building the Supply Base, Supplier Evaluation, Supplier Development	
Inventory Control and Management	**(06 Hours)**
Introduction, EOQ Models with and without shortage, Multi item Deterministic Model, Dynamic and Fluctuating Models, Deterministic Model with price breaks and Probabilistic inventory models, Selective Inventory control	
Aggregate Planning	**(05 Hours)**
Purpose, inputs of aggregate planning processes and strategies, Methods for aggregate,	

Aggregate planning in Services	
Materials Requirement Planning and ERP	**(06 Hours)**
Just in Time, MRP input and output, MRP structure, MRP management, Lot sizing Technique and Extension of MRP, JIT and MRP in services, JIT to Die exchange, ERP : Introduction, Implementation, Advantages	
Short Term Scheduling	**(06 Hours)**
Introduction to Scheduling and Shop floor planning and control, order sequencing rules and their performance based on different evaluation criteria, changeover costs and job sequence, mathematical models of job sequencing	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Jay Heizer, Barry Render and Chuck Munson, Amit Sachan, Operations Management, Pearson Education, 2017
2	Everett E. Adam, Ronald J. Ebert, Production and Operation Management, 5th edition, Prentice Hall of India, New Delhi,2012
3	S. N. Chary, Production & Operations Management, 6th Edition, McGraw Hill, 2019
4	R. Paneerselvam, Production & Operations Management, 3rd edition, Prentice Hall of India, New Delhi,2012
5	S. Chapman, Fundamentals of Production Planning & Control, 1st edition, Pearson Education India, 2007

MEMF111	:	ADVANCED WELDING TECHNOLOGY	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Relate the significance of welding in various industrial sectors.
CO2	Explain the characteristics of welding arc and relate it importance during welding process
CO3	Develop the concepts of various advanced welding technologies
CO4	Analyse the heat flow and metal transfer mechanism in welding
CO5	Determine the solidification mechanism of weld pool
CO6	Compile the quality of weldments by monitoring and controlling the process through advanced techniques

2. Syllabus:

Introduction	**(06 Hours)**
Welding as compared with other fabrication processes, classification, weldability, weld configuration, ASME standards for weldments, scope and applications of welding in various industrial sectors	
Physics of Welding Arc	**(08 Hours)**
Structure and characteristics of welding arc, methods of arc initiation and maintenance, arc stability, voltage distribution along the arc, cathode and anode drops, arc column, thermionic and non thermionic cathode, theories of cathode and anode mechanisms, temperature distribution in the arc, arc efficiency, heat generation at cathode and anode, effect of shielding gas on arc, isotherms of arcs, arc blow, arc welding power sources, heat sources for solid state welding.	
Advanced Welding Processes	**(12 Hours)**
Overview of arc welding processes, flux cored arc welding, plasma transferred arc welding, electro-gas and electro-slag welding, resistance welding, magnetic pulse welding. Theory and mechanism of solid state welding, technique and scope of - friction welding, fiction stir welding, diffusion welding, cold pressure welding, ultrasonic welding, electron beam welding, laser beam welding. Cladding through welding, automation in welding	
Heat Flow and Metal Transfer in Welding	**(08 Hours)**
Calculation of peak temperature, width of heat affected zone, cooling rate and solidification rates, weld thermal cycles. Forces, mechanism and types of metal transfer in various arc welding processes, factors controlling melting rate in various welding processes. Residual stresses and their measurement, weld distortion and its prevention	
Solidification of weld pool	**(05 Hours)**

Principle of solidification of weld metal, modes of solidification, effect of welding parameters on weld structure, grain refinement principle of weld metal, method of weld metal refinement: inoculation, arc pulsation, external excitation	
Inspection and Quality Control of Weldments	**(06 Hours)**
Overview of post weld characterization, weld related discontinuities, overview of standard destructive and nondestructive testing applicable for weldments, inspection of weldments, importance of welding procedure and performance qualification, monitoring and control of welding processes, welding simulation.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Houdlecroft P.T., "Welding Process Technology", Cambridge University Press, 3rd edition, 2004
2	Bowditch, W.A., Bowditch, K. E., "Welding Technology Fundamentals", Goodheart-Willcox Co. Pub., 4th edition, 2009
3	Jeffus, L., "Welding: Principles and Applications", Cengage Learning Pub., 2016
4	Lancaster J F., "Metallurgy of Welding", Elsevier, 6th edition, 1999
5	Parmar R. S., "Welding Engineering and Technology", Khanna Publishers, 2nd edition, 2013

MEMF113	:	COMPUTER AIDED PRODUCTION PLANNING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain different methods of computer aided process planning (CAPP) and distinguish between process planning and production planning.
CO2	Determine the forecast of a product for the given historical data using forecasting models
CO3	Solve the facility layout problems using different algorithms and create part families and machine cells in a manufacturing facility using group technology approach
CO4	Prepare material requirement plan for a product and explain enterprise resource planning (ERP)
CO5	Create schedules for multiple machines/workstations and describe the capacity planning
CO6	Explain different computer aided measurement and inspection techniques

2. Syllabus:

Introduction	**(05 hours)**
Production systems and their types -mass production, batch production and job shop production systems. Introduction to process planning in manufacturing, Role of process planning. Computer aided process planning (CAPP) - variant and generative type process planning	
Computer Aided Forecasting	**(06 hours)**
Introduction to forecasting, sources of data, demand patterns, forecasting errors, forecasting models – Quantitative: moving average, linear regression and exponential smoothing methods; Qualitative - Delphi method	
Facility Layout Planning	**(10 hours)**
Introduction to facility layout, objectives, types of facility layout- line layout, process layout, cellular layout and fixed position layout, advantages and disadvantages. Assembly line balancing, line balancing algorithms- largest candidate rule, Kilbridge and Wester method, and ranked positional weights method. Heuristics of process layout problems - computerized relative allocation of facility technique, automated layout design program and computerized relationship layout planning. Multi objective approach for facility layout planning	
Group Technology	**(06 hours)**
Introduction, benefits of group technology, part families, part classification and coding, applications of GT. Algorithms and models for Group Technology - Rank order clustering algorithm and Bond energy algorithm	

Material Requirement Planning	(06 hours)
Introduction, Objective of the MRP system, inputs to the MRP System – product structure or bill of materials (BOM), master production schedule (MPS) and inventory status file. MRP calculations. Manufacturing resources planning (MRP-II). Enterprise resource planning (ERP)	
Scheduling And Capacity Planning	**(07 hours)**
Introduction, Single machine scheduling –shortest processing time rule, weighted mean flow time rule, earliest due date rule, model to minimize total tardiness, branch and bound algorithm. Introduction to parallel processors under single machine scheduling. Flow shop scheduling – Johnson's algorithm. Job shop scheduling. Capacity planning – measure of capacity, capacity strategies, tools for capacity planning	
Computer Aided Measurement and Inspection	**(05 hours)**
Computer Aided Testing, Contact and Non-contact type inspection, Co-ordinate measuring machines (CMM), types of CMM, Applications of CMM and its Benefits, Laser viewers for production profile checks, Machine vision technology, Microprocessors in metrology	

(Total Lecture Hours: 45)

3. Books Recommended:

1	R. Panneerselvam. Production and Operations Management, 3rd Edition, PHI Learning Pvt Ltd, 2015
2	M. P. Groover. Automation production systems and computer integrated manufacturing, 5th edition, Pearson Edu Ltd, 2019
3	E. E. Adam, R. J. E Bert. Production and Operations Management, 5th Edition, Prentice Hall of India, 2015
4	J. Heizer, B. Render, C. Munson. Operations Management, Pearson Edu Ltd, 12th Edition, 2017
5	S. N. Chary. Production and operations management. McGraw Hill Education (India) Pvt. Ltd, 6th Edition, 2019

MEMF115	**:**	**METAL CUTTING AND TOOL DESIGN**	**L**	**T**	**P**	**Credits**
			3	**0**	**0**	**03**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Develop and calculate the relations for chip reduction coefficient, shear angle, shear strain, forces, power, specific energy and temperatures associated with orthogonal cutting
CO2	Select cutting fluids, cutting tool materials and tool geometry for improving machinability and tool life for selected condition
CO3	Relate thermals aspects and form of tool wear with tool life and compute tool life under given condition
CO4	Select tool material and tool geometry for cutting tool for given application
CO5	Select suitable type of die for effective operation
CO6	Design the die and strip layout for effective utilization and increased production

2. Syllabus:

Mechanics of Metal Cutting	**(14 Hours)**
Metal cutting principles, classification and mechanism of chip formation, types of chips, chip breakers, chip thickness ratio, shear plane, shear angle, shear strain, shear strain rate, shear angle relationships, velocity relationships, force analysis in orthogonal cutting; force analysis in drilling and milling process, types of tool dynamometer.	
Thermal aspects in Machining	**(06 Hours)**
Thermal aspects in machining, temperature distribution, temperatures in primary deformation zone, temperatures in secondary deformation zone, the measurement of cutting temperatures.	
Tool Life	**(06 Hours)**
Forms of wear in metal cutting, tool life criteria for different tool materials, tool life, factors affecting tool life, tool failure, Basic requirements of tool materials and major classes of tool materials, cutting fluids, economics of machining.	
Design of Cutting Tools	**(10 Hours)**
Properties required for tooling materials, various tool materials, Jigs and fixtures, Design of cutting tools, Selection of carbide cutting tools.	
Design of Press Tools	**(08 Hours)**
Die-design fundamentals; Material of die components, Design of Blanking and Piercing die, Progressive die, Strip-layout, Deep drawing die.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	G. Boothroyd and W. A. Knight, Fundamentals of machining and machine tools, Taylor and Francis, 3rd Edition, 2006
2	M. C. Shaw, Metal Cutting Principles, Oxford University Press, 2nd edition, 2008
3	G. K. Lal, Introduction to Machining Science, New Age International Publishers, 3rd edition, 2013
4	A. B. Chattopadhyay, Machining and Machine Tools, Wiley India, 1st edition, 2013
5	Cyril Donaldson, George H. Lecain and V. C. Goold, Tool design, 4th edition, Tata-McGraw Hills, 2010

MEMF117	:	CAD FOR MANUFACTURING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Understand and describe geometric transformation techniques in CAD.
CO2	Design surface models for given engineering applications.
CO3	Develop mathematical equation to represent curves
CO4	Create model of a given engineering component using solid modeling techniques
CO5	Design and analyse a given engineering component or assembly
CO6	Describe and create interfacing design and drafting for an application with CAD standards

2. Syllabus:

Introduction	**(05 Hours)**
Basics of Computer Aided Design, Introduction to Computer graphics, DDA and Bresenham's algorithm for generating various figures and Basics of CAD hardwares.	
2D/3D Transformation	**(06 Hours)**
2D Transformation of geometries and 3D Transformations for Translation, Rotation, Scaling, Symmetry, Reflection, and Homogeneous Transformations, Orthographic Projections, Axonometric Projections, Oblique Projections, Perspective Transformation.	
Representation of Curves	**(06 Hours)**
Representation of curves – Explicit and Implicit Equations Parametric and non-parametric Curves, Splines, Bezier, B-Splines and generation of surfaces.	
Solid Modeling	**(08 Hours)**
Introduction to Drafting and modelling of solids, Coordinate system, Fundamentals of solid modeling, Customization, 3D sketches, Datum features, Modeling operation Strategyand creating features, Geometric constraints, Modeling aids & tools, Generalized, views, Presentation of dimensioning / tolerances/symbols & annotation, Associatively, Parent child relationship, Parametric design, Programming techniques in drafting/ modeling/analysis, Concept of computer animation, Properties calculation Hidden line and surface removal.	
Surface Design & Analysis	**(08 Hours)**
Different approaches of creating and assembly. Surface design, and Surface analysis	
CAD Standards	**(04 Hours)**
Standards in CAD, Graphics and computing standards, Data exchange standards, Exchange format, Design database, Interfacing design and drafting, Mechanical assembly.	
Applications of CAD in Manufacturing	**(08 Hours)**
Introduction to CAD tools and softwares, Role and applications of CAD in manufacturing domains like machining, forming, tool design, die design, assembly, 3D printing, etc.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Hearn Donald & Baker M. Pauline, “Computer Graphics”, Prentice-Hall of India Pvt. Ltd., 2nd Edition, 1997
2	David F. Rogers & J. Alan Adams, “Mathematical Elements for Computer Graphics” McGraw Hill, 2nd Edition, 1990
3	Zeid Ibrahim, “CAD/CAM - Theory and Practice”, McGraw Hill, International Edition, 1998
4	McMohan Chris, “CAD/CAM: Principles, Practice and Manufacturing ”, Prentice Hall, 1999
5	Rao, P.N. “CAD/CAM: Principles and Applications”, McGraw Hill Publication, 2nd Edition

MEMF119	:	MANUFACTURING METALLURGY	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the mechanism of solidification of metals and alloys
CO2	Explain and distinguish various deformation mechanisms under different conditions
CO3	Determine heat treatment required for given conditions
CO4	Identify the equilibrium condition under different phase transformation using TTT or CCT diagram
CO5	Perform mechanical testing of given part
CO6	Understand metallurgical aspects of manufacturing processes

2. Syllabus:

Liquid Metallurgy Processing	**(10 Hours)**
Introduction, Nucleation in pure metals, undercooling, recalescence, homogeneous nucleation, heterogeneous nucleation, growth and interface stability, cooling curve and solidification structures of pure metal, single crystals, equiaxed microstructures, cooling curve and solidification structures of solid solutions, Constitutional Undercooling, Solute redistribution during solidification, Cellular Structures, dendritic structures, segregation during cooling, eutectic phase solidification, off-eutectic alloys, peritectic alloys, solidification of ingot and casting, gas solubility and gas porosity, solidification during quenching from the melt (metal glasses).	
Plastic Deformation of Metals	**(10 Hours)**
Metallic crystal structure, SC, FCC, BCC, HCP, miller indices, single crystal vs polycrystal, Segregation of Impurities Line and Points Defects in Crystals Elasticity, yield criteria, and plasticity; defects in crystals; elements of dislocation theory – types of dislocations, slip and twinning, source and multiplication of dislocations, stress fields around dislocations, partial dislocations, dislocation interactions and reactions; strengthening mechanisms; tensile, fatigue and creep behaviour; superplasticity; fracture – Griffith theory, basic concepts of linear elastic and elastoplastic fracture mechanics, ductile to brittle transition, fracture toughness.	
Solid State Phase Transformation	**(08 Hours)**
Phase equilibria involving eutectoid and peritectoid transformations, TTT and CCT diagrams, hardenability, Heat Treatment of Ferrous and Non Ferrous Alloys viz., annealing, normalizing, quenching, tempering and precipitation hardening.	
Fundamental Mechanical Properties	**(08 Hours)**
Tensile Strength, Hardness Tests Impact Tests, creep, fatigue, fracture toughness and formability Other Destructive Tests, Non-destructive Tests.	
The Industrial Shaping of Metals	**(09 Hours)**
Sand Casting, Die Casting and Allied Processes, Fusion and Non Fusion Welding	

Processes, Hot-working Processes, Cold-working Processes, Sintering from a Powder, Machinability of Metals and Alloys

(Total Lecture Hours: 45)

3. Books Recommended:

1	Balasubramaniam R., Callister's Materials Science and Engineering, 8th Ed., Willy, 2010
2	Askeland R.D. and Askeland D., Materials Science and 2010 Engineering, Ceneage, 2010
3	Ghosh A. and Mallick A. K., Manufacturing Science, Affiliated East West Press, 2001
4	Porter, D.A., Easterling, K.E., and Sherif, M.Y., "Phase Transformations in Metals and Alloys", 3rd Ed., CRC Press, 2009
5	Rajan, T.V., Sharma, V.P., Sharma, A., "Heat Treatment Principles and Technique", Prentice- Hall, 2006

MEMF121	:	INDUSTRIAL ROBOTICS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Identify suitable actuator and sensor to monitor and control a given product or process
CO2	Describe the evolution, classification, structures and drives for robots
CO3	Select suitable pneumatic/hydraulic or electro-pneumatic/electro-hydraulic system for a given task
CO4	Design and analyse robot cell layout for given application
CO5	Develop PLC programs using suitable language for a given task.
CO6	Apply AI and Expert systems for robot programing of given task or cell layout

2. Syllabus:

Introduction	**(02 Hours)**
Robot Definition, Applications, Robot Anatomy, Robot Classifications and Technical Speciation's, Serial robots and Parallel robots.	
Robot Sensors & Actuators	**(06 Hours)**
Contact and non-contact sensors; Position, Velocity, Acceleration and Force/Torque sensors; Robot vision and their interfaces Pneumatic, Hydraulic and Electric Actuators, Stepper Motors, DC and AC motors, Selection of Motors, Gearboxes and Robot End-effectors	
Transformations	**(06 Hours)**
DOF of a Robot; Understanding Pose or Configuration; Homogeneous transformation matrix, Denavit - Hartenberg (DH) Parameters, Forward Kinematics, Tools and Base Calibration. Velocity Relations and Robot Jacobean, Force and Velocity Ellipsoids, Inverse Kinematics.	
Introduction to Robot Statics & Control	**(06 Hours)**
Gravity Compensation, Effect of external forces. Introduction to Robot Dynamics; Euler-Lagrange Formulation, Obtaining generalized equation of motion. Transfer functions and Block Diagram Representation, Proportional, Integral and Derivative Control	
Pneumatic/Hydraulic Systems and Circuit	**(06 Hours)**
Introduction to pneumatic/Hydraulic Systems and Their Components, Various types of valves, and their applications. Pneumatic/Hydraulic Circuit Design Approach and Examples. Pneumatic/Hydraulic Circuit Sequence, Limit Switches, Limitations of Pneumatic/Hydraulic Systems. Basics of Electro-Pneumatic and Electro-Hydraulic/Electro-Hydraulic Systems and Their Components, Circuit Design, Relay Control and Sequence Control Applications with Example	
Robot Cell Design and Application	**(05 Hours)**
Robot work cell design and control, Safety in Robotics, Robot cell layouts, Multiple Robots and machine interference, Robots cycle time analysis, Industrial application of	

robots	
PLC, Robot Programming, Artificial Intelligence and Expert System	**(14 Hours)**
Introductions to PLCs, Inputs and Outputs and their types. Interfacing of I/O devices with a PLC. Programming Languages and Introduction sets, Ladder Logic and Applications Methods of Robot Programming, Characteristics of task level languages lead through programming methods, Motion interpolation, Artificial intelligence, Basics, Goals of artificial intelligence, AI techniques, Problem representation in AI, Problem reduction and solution techniques, Application of AI and ES in Robots	

(Total Lecture Hours: 45)

3. Books Recommended:

1	John J Craig, Introduction to Robotics: Mechanics and Control, Prentice Hall, 3rd edition, 2004
2	Subir Kumar Saha, Introduction to Robotics, McGraw Hill, 2nd edition, 2014
3	Stamatios Manesis, and George Nikolakopoulos, Introduction to Industrial Automation, CRC Press, 2nd edition, 2018
4	W. Bolten, Mechatronics, Pearson Publishers, 4th Edition, 2010
5	Saeed B Niku, “Introduction to Robotics: Analysis, Systems, Applications “,Pearson Education India, PHI, 2nd edition, 2003

MEMF123	:	ADVANCED METROLOGY AND COMPUTER AIDED INSPECTION	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Suggest suitable techniques to minimize measurement errors and uncertainty
CO2	Identify suitable methods and devices for dimensional metrology of given part
CO3	Calculate limits, fits and tolerances and design limit gauges for given condition
CO4	Assess surface roughness and form errors for given surface
CO5	Identify devices for computer aided inspection of given form and part
CO6	Deduce requirement of laser metrology for given application

2. Syllabus:

Basic Concepts of Measurement	**(03 Hours)**
Generalized measurement system, Classification of measurements, Classification of measurement, Calibration, Measuring instruments and their properties.	
Uncertainty Analysis	**(03 Hours)**
Measurement and error, Type A and Type B categories of uncertainty, Combined type A and type B, Evaluation of uncertainty.	
Measurement of Length and Angle	**(05 Hours)**
Length measurement, Angle measurements, Direct and indirect methods, Standards for length measurement, Length measuring instruments, Angle measuring instruments, Setting errors with sine-bar, Measurement of angles over 45^0 , Internal taper measurements.	
Limits, Fits and Tolerances	**(07 Hours)**
Need for limit systems, Interchangeability, types of interchangeability, Limits and fits, Tolerance dimensions, Terns and definitions, Published standards for limits and fits system, Types of fits, Design of limit gauges, Geometric tolerances key aspects, symbols, Tolerance frame, Datum symbols, Tolerance feature and Interpreting drawing.	
Form Metrology	**(06 Hours)**
Measurement of roughness, waviness, flatness, roundness, cylindricity, radius, screw, gear, Methods of improving accuracy & surface finish, Influence of forced vibration on accuracy, Dimensional wear of cutting tools and its influences on accuracy.	
Amplifying Devices	**(04 Hours)**
Tool Maker's microscope, Profile projector, Comparators: Mechanical, Pneumatic, optical, electric and electronic.	
Computer Aided Metrology	**(10 Hours)**
Coordinate measurement machine (CMM), Applications, Advantages, Type of CMM & applications, Constructional features of CMM, Probes touch trigger probe and non contact trigger probers, Operation and Programming, Examination of surface texture, Possible sources of error in CMM, Image Analysis and Computer Vision.	

LASER Metrology	**(07 Hours)**
Types of laser, Laser in engineering metrology, methods of laser metrology, Laser interferometer, Laser alignment telescope, Laser micrometer, On-line and in-process measurements of small diameter, large displacement, Roundness and surface roughness using LASER, Micro profile and topography measurements, Testing of machine tools.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	J. F. W. Galyer and C. R. Shotbolt, Metrology for Engineers, Thomson Learning, 5th Edition, 1993
2	I. C. Gupta, A Text Book of Engineering Metrology, Dhanpat Rai and Sons, 4th Edition, 2018
3	M. Mahajan, A text-book of Metrology, Dhanpat Rai & Co, 2014
4	R. K. Jain, Engineering Metrology, Khanna Publishers, 19^{th} edition , 2015
5	C. Dotson, Dimensional Metrology, Delmar Cengage Learning, 1st Edition, 2009

MEMF125	:	FAILURE ANALYSIS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Identify and illustrate sources of failures during manufacturing, services and maintenance
CO2	Analyse the type of failures in the components by applying fracture mechanics principles
CO3	Suggest and explain different types of failure analysis tools for industrial solution
CO4	Compute extent of failure using different industrial engineering tools
CO5	Identify suitable NDT techniques applied for failure analysis of industrial problem
CO6	Design and implement failure analysis strategies to diagnose failure indications, identify failure mechanisms, and determine reasons of failure in components

2. Syllabus:

Introduction	**(06 Hours)**
Need and scope of failure analysis and prevention, Engineering disasters and understanding failure, Fundamental sources of failures: Examples of different deficient designs.	
Fundamental Sources of Failures	**(07 Hours)**
Imperfections in base metals , Improper manufacturing processes and Improper service conditions, Poor assembly, Service and maintenance.	
Industrial Engineering Tools for Failure Analysis	**(12 Hours)**
Pareto diagram, Fish bone diagram, Fault tree analysis, Failure rate analysis, mean failure rate, mean time to failure, mean time between failure, Graphical representation of Fd,, Z and R. Generalization in graphical form, integral form, Hazard models, systems reliability, availability, maintenance, overall equipment effectiveness, Total Productive Maintenance (TPM), Failure Mode and Effect Analysis (FMEA)	
NDT & DT for Failure analysis:	**(06 Hours)**
Non-destructive testing for failure analysis, Destructive testing, selection, preservation, cleaning & sectioning of samples, Macroscopy of fracture surfaces-I, Macroscopic of fracture surfaces- II, Determination of Type of Fractures and chemical analysis	
General Procedures for Failure Analysis and case studies	**(14 Hours)**
Types of Failure and Stress, Ductile and Brittle Fractures, Fatigue Failures, Wear Failures, Corrosion Failures, Elevated-Temperature Failures, use of fracture mechanics and fracture toughness principles in failure analysis and analysis findings and report/recommendation writing. Simulated test and analysis of evidences and results. Different case studies: Failure analysis of welded joints in different sectors, Failure analysis of 3D Printed polymer parts, Failure analysis of manufacture defects induced tubes, failure analysis of deep drawing dies in manufacturing of automotive parts and aerospace components	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Brett A. Miller, Roch J. Shipley, Ronald J. Parrington, and Daniel P. Dennies, Failure analysis and prevention, ASM Handbook, 2002
2	Gordon W Powell, Salah E Mahmoud, Metals Hand Book Volume 11: Failure Analysis and Prevention ASM Hand book 9th Edition, 1986
3	Abdel Salam Hamdy Makhlouf, Mahmood Aliofkhazraei,_Handbook of Materials Failure Analysis with Case Studies from the Aerospace and Automotive Industries, Butterworth- Heinemann Publications 2015.
4	Jones DRH, Failure analysis of Case studies II, Pergaman Publications, 2001.
5	Govil AK, Reliability Engineering, Tata McGraw-Hill, 1983

MEMF127	:	OPTIMIZATION TECHNIQUES	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Understand the concept of optimization, related terms and formulate mathematical models for practical problems based on the information provided
CO2	Use linear programming to solve real life linear programming problems
CO3	Solve transportation and transhipment problems, travelling salesman problem and integer programming
CO4	Determine solutions that will be deployed in real world situations after conducting sensitivity and post optimality analysis
CO5	Apply classical methods to solve nonlinear programming problems
CO6	Use evolutionary algorithms to solve complex engineering problems where classical methods are not suitable

2. Syllabus:

Introduction	**(05 Hours)**
Introduction to Optimization, Linear Programming – Formulation, Graphical method, simplex method and special cases	
Sensitivity and Post Optimality Analysis	**(08 Hours)**
Sensitivity Analysis and post optimality analysis of linear programming problems – changes in resources and objective function, changes affect feasibility and optimality, duality, dual simplex algorithm, generalize simplex algorithm	
Special Types of Linear Programming Problems	**(06 Hours)**
Transportation problems, Transshipment problems, Travelling salesman problems, Integer programming	
Introduction to MATLAB and Solving Linear and Nonlinear Problems using MATLAB	**(07 Hours)**
Introduction to MALAB, creating and manipulating vectors and matrix, user defined function, special built-in function to create special vectors and matrices, symbolic math, built-in function to solve linear programming problems	
Nonlinear Programming Problems	**(05 Hours)**
Nonlinear Programming problems: Graphical method, convex function and convex region, necessary and sufficient conditions, Lagrangian method, Karush-Kuhn-Tucker (KKT) conditions, solving nonlinear problems using MATLAB	
Evolutionary Algorithms	**(14 Hours)**
Introduction to evolutionary algorithm, introduction to multi-objective optimization, genetic algorithms, differential evolution algorithm, Particle swarm optimization, tabu search, simulated Annealing technique, solving real life engineering problems using MATLAB.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Hillier, Frederick S. "Introduction to operations research.", 1967
2	Taha, Hamdy A. Operations research: an introduction. Vol. 790. Upper Saddle River, NJ, USA: Pearson/Prentice Hall, New Jersey, 2011
3	Rao S.S., “Optimization Theory & Applications”, Wiley Eastern, USA, 1990.
4	Vasuki, A. Nature-Inspired Optimization Algorithms. CRC Press, Florida, 2020
5	Malik A. K. , Yadav S. K. , Yadav S. R., “Optimization Techniques”, I.K. International Publishing House ,India, 2013

MEMF129	:	THEORY OF PLASTICITY	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe basic concepts of plasticity and plastic deformation mechanism in metals.
CO2	Develop analytical modeling and skills of engineering application related to plastic deformation
CO3	Apply empirical equations for equilibrium of given conditions
CO4	Analyse and compute the yielding of a material according to different yield theory for a given state of stress
CO5	Apply plasticity concepts to given problems of metal forming
CO6	Compute stress and strain for given conditions

2. Syllabus:

Basic Theory	**(08 Hours)**
Introduction to Tensor, Concept of Stress and Strain, Principle Stresses & Strains, Stress & Strain Invariants, Deviatoric Stress & Strain, Octahedral Normal and Shear Stresses and Strains, Spherical Stress, Plane Stress and Plane Strain, Strain Rate and Strain Rate Tensor, Cubical Dilation, Stress Transformation, Compatibility and Constitutive Equation, Generalized Hooke's Law.	
Theory of Plasticity	**(13 Hours)**
Theory of Plastic Flow, Plastic Deformation of Metals: Crystalline Structure in Metals, Crystal Imperfections, Dislocation Geometry and Energy, Dislocation Mechanics, Mechanism of Plastic Deformation, Factors Affecting Plastic Deformation, Strain Hardening, Recovery, Recrystallization and Grain Growth, Flow Figures or Luder's Cubes. Differential Equations of Equilibrium, Equivalent Stress and Strain, 3D Stress Analysis, Idealised Stress-Strain Diagrams for different material models, Empirical Equations, Levy-VonMises Equation, Prandtl-Reuss and Saint Venant theory, Experimental Verification of Saint Venant's.	
Yielding Criteria in Plasticity	**(12 Hours)**
Introduction, Yield or plasticity Conditions, Significance of the Theories of Failure, Von Mises's, Tresca's and Anisotropic Yield Criteria, Geometrical Representation, Halgh-Westergard Stress Space Representation of Yield Criteria, Yield Surfaces of Tresca's and Von Mise's, Yield Locus (Two Dimensional Stress Space), Experimental Evidence for Yield Criteria, Plastic Flow of Anisotropic Material, Bauschunger Effects, Isotropic and Kinematic Hardening, Advanced Anisotropic Criteria in Sheet Metals like Barlat or BBC Yield Criteria.	
Applications of Plasticity	**(12 Hours)**
Introduction to Bending of Beams, Stages of Plastic Yielding, Analysis of Stresses, Linear and Nonlinear Stress Strain Curve, Introduction to Torsion Bars, Plastic Torsion of a Circular Bar, Elastic Perfectly Plastic Material, Elastic Work Hardening of Material,	

Theory and application of Slip Line Field, Basic Equations for Incompressible Two Dimensional Flows, Continuity Equations, Stresses in Conditions of Plain Strain, Convention for Slip Lines, Geometry of Slip Line Field, Properties of the Slip Lines, Construction of Slip Line Nets, Simple Problems of Forging Extrusion, Drawing and Indentation, Bound Theorem and Application.

(Total Lecture Hours: 45)

3. Books Recommended:

1	Chakraborty J., Theory of Plasticity, Elsevier, 3rd Edition , 2006
2	Sadhu Singh, Theory of Plasticity and Metal Forming Process, Khanna Publishers, 3rd edition 2008
3	L S Srinath, Advanced Mechanics of Solids, McGraw Hill Education, 3rd edition, 2009
4	Valentin Molotnikov, Antonina Molotnikova, Theory of Elasticity and Plasticity, Springer International Publishing, 2021
5	H. Jane Helena. Theory of Elasticity and Plasticity, Prentice Hall India Pvt. Limited, 2017

MEMF107	:	LABORATORY PRACTICE-I	L	T	P	Credits
			0	0	4	02

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Understand and demonstrate operation of identified machine/instrument/equipment
CO2	Perform given practical task independently on machine/instrument/equipment
CO3	Analyse and evaluate the observations of identified practical task
CO4	Represent results graphically and deduce conclusions therein
CO5	Demonstrate practical skills to work on identified problem
CO6	Demonstrate skills of team effort and coordination through group practical performance

Practicals:

Students will perform practicals in various laboratories. The indicative list (but not limited to) of practicals is as under:

1. To understand the effect of selected welding process parameters on weld bead geometry and welded joint characteristics.
2. To understand microstructural characterization techniques for as weld and post weld heat treated weldments.
3. To understand cladding approach through plasma transferred arc welding process
4. To understand the correlation of virtual/reality-based welding with actual welding.
5. Evaluation of the effect of process parameters on cutting force during given machining process
6. Estimation of chip reduction co-efficient and shear angle during orthogonal cutting
7. Preparation of single point cutting tool with a given tool geometry
8. Estimation of tool life of a single point cutting tool
9. Evaluation of dimensional and geometrical accuracy on a given part using CMM
10. Mechanical testing of a given part (machined part/welding part/ composite)

MEMF102	:	COMPUTER INTEGRATED MANUFACTURING	L	T	P	Credits
			3	1	2	05

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe different types of Automation and CIM.
CO2	Develop the CNC Program for the given geometry for Drilling, Milling and Turning machines
CO3	Develop the part program using APT
CO4	Analyze the production flow based on part classification, identification and coding.
CO5	Evaluate the different types of flexibilities in manufacturing
CO6	Explain and evaluate types and steps of computer aided process planning

2. Syllabus:

Introduction to CIM	**(04 Hours)**
Introduction to automation, Types of automation, Automation principles and strategies, Definition of CIM, CIM wheel, Evolution of CIM, Benefits of CIM, CIM hardware and software, Nature and role of the elements of CIM system, Development of CIM.	
Computer Aided Manufacturing	**(18 Hours)**
Components of NC/CNC system, Specification of CNC system, Classification of CNC machines, Constructional details of CNC machines, Axis designation, CNC control loops. Basic programming terms, Programming formats, Preparatory command, Miscellaneous functions, Machine zero, work zero and tool zero, Work offsets, Tool length offset and setup methods, Cutter radius offset, Machine zero return, Part programming for milling - linear and circular interpolation, subprogram, fixed/canned cycles, mirrors commands, machining large hole pattern, polar coordinates, round and rectangular pocket machining and cycles, subroutines, mirror, Part programming for lathe - lathe cycles, with and without tool nose radius feature, repetitive fixed cycle	
Part Programming with Automatically Programmed Tools (APT)	**(05 Hours)**
Computer aided part programming, APT: Geometry, motions and auxiliary commands, drill cycle commands, programming for geometry and drill cycle and hole pattern	
Group Technology	**(08 Hours)**
Definition, implementation considerations, benefits and applications, G.T. methods - visual search method, production flow analysis, Parts classification and coding, Design and manufacturing attributes, Concept of composite component, Rank order clustering, machine cell formation, Cell group tooling, Design rationalization, possibilities of integration with CAD/CAM.	
Flexible Manufacturing System	**(07 Hours)**
Introduction, General Considerations for FMS, types of FMS, Flexibilities, their measurements, Computer control in FMS, Automated material handling systems, AGVs, Automatic storage and retrieval systems, Manufacturing cells, cellular v/s	

flexible manufacturing	
Computer Aided Process Planning	**(03 Hours)**
Introduction to CAPP, Route card, Manual and computer aided process planning, steps, and types	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Krar, S.F. and Gill, A., CNC: Technology and Programming, McGraw-Hill, 1989
2	Groover, M.P., Automation, production systems, and computer-integrated manufacturing. Pearson Education India, 5th Edition, 2019
3	P. Radhakrishnan, S. Subramanyan, and V. Raju, CAD/CAM/CIM, New age International publishers, 3rd edition, 2011
4	P. N. Rao, CAD/CAM Principles and Applications, Tata McGraw Hill, 2nd Edition, 2006.
5	S. Kant Vajpayee, Principles of Computer Integrated Manufacturing, PHI, New Delhi, 1st edition, 1998

List of Practicals:

1. Demonstration of CNC Milling machine with user interface and calculate the Co-ordinates of given geometry in absolute and increment mode for cutter path.
2. Introduction of G codes and M codes and write the CNC part programming for a given geometry using Linear, Circular interpolation. (Using FANUC Controller)
3. Write the CNC part programming for a given geometry using Mirror and Subroutine. (Using FANUC Controller)
4. Write the CNC programming for a given geometry using Polar Co -ordinate for drilling cycles.
5. Write the CNC part programming for a given geometry using Tool Radius Compensation and Repeat loop for Peck Drilling Cycle. (Using FANUC Controller)
6. Introduction and programming of all canned cycle of Milling machine. (Using FANUC controller)
7. Demonstration and study of CNC Lathe machine with sample programming.
8. Write CNC programming for given geometry (Lathe) using stock removal cycles (Using FANUC controller)
9. Demonstration of FMS setup. (AS / RS, AGV, CNC Lathe, CNC Milling, Robot & CMM setup
10. Demonstration of Advance manufacturing Machines like EDM (Electro Discharge Machine), Micro Machine, Vision Measuring System.

MEMF104	:	ADDITIVE MANUFACTURING PROCESSES	L	T	P	Credits
			3	0	2	04

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Classify additive manufacturing processes and explain generic steps in additive manufacturing
CO2	Explain principle, and mechanism of solid based, liquid based and powder based additive manufacturing processes
CO3	Select a suitable additive manufacturing process for a given material and application
CO4	Identify software related issues in additive manufacturing; and post processing aspects including defects and part quality
CO5	Design and optimize a given part following guidelines and rules for part building
CO6	Elaborate state of art in additive manufacturing

2. Syllabus:

Introduction	**(04 Hours)**
Definition, classification, stages of generic additive manufacturing process, benefits, applications, process selection, evaluation, benchmarking, future growth and opportunities	
Solid Based Processes	**(06 Hours)**
Basic principle and working of Fused Deposition Modelling process, liquification, solidification and bonding, bio extrusion, Laminated Object Manufacturing process, Multi jet process, typical materials and applications, safety considerations	
Liquid Based Processes	**(06 Hours)**
Photo polymerization, principle and working of stereo lithography apparatus, scanning techniques, curing processes, typical materials and applications, safety considerations	
Powder Based Processes	**(07 Hours)**
Powder fusion mechanism, powder handling and recycling, Principle and working of Selective Laser Sintering, Laser Engineering Net Shaping process, Electron Beam Melting, process parameters, typical materials and applications, safety considerations	
Additive Manufacturing Data Formats, Pre-processing & Post processing	**(08 Hours)**
Additive manufacturing file formats, Defects and Issues in Data Formats; Pre-processing - Part orientation and support structure generation, Model Slicing, Contour Generation, Tool Path Generation, Build File preparation, Machine Set-up; Post Processing – Product quality evaluation, support structure removal, Improvement of finish, geometry and aesthetics	
Design For Additive Manufacturing	**(08 Hours)**
Core concepts and objectives, Principles of design for manufacturing and assembly, Constraint approach to design for additive manufacturing: Guidelines and rules for part building, Topology optimization and generative design, exploring design freedom, design tools	

Recent Trends in Additive Manufacturing	(06Hours)
Composite 3D printing, Bio 3D printing of tissues and organs, Clay and Concrete 3D printing, 3D food printing, 3D printing in space, 4D printing.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	I. Gibson, D. Rosen, B. Stucker, Additive Manufacturing Technologies, Springer Publisher, 2nd Edition, 2015
2	C. K. Chua, K. F. Leong, C. S. Lim, Rapid Prototyping – Principles and Applications, World Scientific, 3rd Edition, 2010
3	C. P. Paul, A. N. Anoop, Additive Manufacturing – Principles, Technologies and Applications, Mc Graw Hill Education (I) Pvt. Ltd., 1st edition, 2021
4	A. Bandyopadhyay and S. Bose, Additive Manufacturing, CRC Press, 2nd edition, 2015
5	Diegel, Olaf, Axel Nordin, and Damien Motte. A Practical Guide to Design for Additive Manufacturing. Springer Singapore, 1st edition, 2019

List of practicals:

1 To study the STL file preparation of a given CAD model using selected software
2 To 3D print a given part using filament extrusion process
3 To 3D print a given part using photo polymerization process
4 To fabricate polymer filament and study its suitability for 3d printing
5 To study the effect of infill pattern and infill density on mechanical strength of a given 3D printed part
6 To prepare cellular structures using different additive manufacturing techniques
7 To fabricate fiber reinforced polymer composite part using composite 3D printing process
8 To study of the post-processing techniques for 3D printed components
9 To study clay 3D printing process
10 To prepare report on demonstration of laser based additive manufacturing process

MEMF110	:	METAL CASTING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe the fundamentals and steps involved in metal casting
CO2	Determine suitable strategy for melting and solidification of metal for sound casting
CO3	Explain designing of gating and riser system.
CO4	Analyze the metallurgical aspects of the solidified metals
CO5	Understand Inspection, quality control and testing of cast products.
CO6	Select suitable casting process for given industrial application

2. Syllabus:

Introduction	**(03 Hours)**
Casting as a process of Manufacturing, foundry industry in India, challenges for foundry industry in India, important industrial sectors using casting	
Moulding Processes, Equipment and Mechanization	**(07 Hours)**
Different types of moulds, moulding materials and moulding processes, pattern and other mould making equipments, forces acting on moulds, mould factors in metal flow, moulding factors in casting design, different types of binders and their use in mould and core making	
Melting of Metals and Alloys for Casting	**(07 Hours)**
Brief mention of various melting units, melting and post melting treatments, , Cupola, Charge Calculations, Other Furnaces, Inoculation Practice for Gray and Ductile Iron, Degassing, Ladles, Casting Cleaning melting practices as adopted for a few metals and alloys such as Al, Cu, steels.	
Solidification of Metals and Alloys	**(09 Hours)**
Nucleation, Growth, Role of alloy constitution, Thermal conditions and inherent nucleation and growth conditions in the liquid melt, Time of solidification and Chowrinov rule, concept of directionality in solidification Significance and practical control of cast structure	
Principles of Gating and Risering	**(08 Hours)**
Feeding characteristics of alloys, types of gates and risers, time of solidification and Chvorinov rule, Wlodawer system for feeder head calculations, gating ratio, concept of directionality in solidification, yield of casting and prescription for its augmentation.	
Special Casting Methods	**(06 Hours)**
Shell Moulding, Precision Investment Casting, Permanent Mould Casting, Die Casting, Vacuum Die Casting, Low Pressure Die Casting, Centrifugal Casting, Continuous Casting, Squeeze Casting, Slush Casting, Vacuum Casting, Thixocasting, centrifugal casting, full mould casting, quick casting , evaporative pattern casting.	
Casting Defects & Quality Control	**(05 Hours)**

A detailed analysis of casting defects, their causes and prescription of remedial measures. Non-Destructive Testing (NDT): Dye Penetrant Testing, Fluorescent Powder Testing, Magnetic Particle Inspection, Radiographic Inspection, Ultrasonic Testing, Eddy Current Inspection.

(Total Lecture Hours: 45)

3. Books Recommended:

1	Ramana Rao, T. V., Metal Casting, Principles and Practice, New Age International (P) Ltd. 2nd Edition, 2019
2	Mahi Sahoo, Principle of Metal Casting, Mcgraw Hill, 3rd Edition, 2017
3	Jain, P. L., Principles of Foundry Technology, Tata McGrawHill Edu. 4th edition, 2006
4	Hein, R. W., Loper, C.R. and Rosenthal, P.C., Principles of Metal Casting, Tata-Mc Graw Hill. 1st Indian edition, 2017
5	Scrope Kalpakjian, "Manufacturing processes for Engineering Materials", Addision, Wesley, 3rd edition, 1997

MEMF112	:	FINITE ELEMENT METHODS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the fundamental concepts of the theory of the finite element method.
CO2	Develop element characteristic equation and generation of global equation
CO3	Devise suitable boundary conditions to a global equation for bars, trusses and beams
CO4	Evaluate the governing FE equations for solving 1D and 2D problems
CO5	Apply the FE method for identified problems
CO6	Perform finite element analyses and evaluate the results of a select set of manufacturing processes

2. Syllabus:

Introduction to Finite Element Method	**(05 Hours)**
Relevance of finite element analysis in design, Modeling and discretization, Interpolation, Elements, Nodes and degrees-of-freedom, Applications of FEA. One-Dimensional Elements and Computational Procedures: Bar elements, Beam elements, Bar and beam elements of arbitrary orientation, Assembly of elements, Properties of stiffness matrices, Boundary conditions, Solution of equations, Mechanical loads and stresses, Thermal loads and stresses.	
Truss, Beam and 2-D Elements	**(08 Hours)**
Interpolation and shape functions, Element matrices, Linear triangular elements (CST), Quadratic triangular elements, Bilinear rectangular elements, Quadratic rectangular elements, Solid elements, Higher order elements, Development of Truss equations, Development of beam equations, Nodal loads-stress calculations.	
Isoperimetric Elements	**(08 Hours)**
Bilinear quadrilateral elements, Quadratic quadrilaterals, Hexahedral elements, Numerical integration, Quadrature, Static condensation, Load considerations, Stress calculations, Examples of 2D and 3D applications.	
Finite Elements in Structural Dynamics Applications	**(10 Hours)**
Solid and Structural Mechanics Applications: One dimensional problems static analysis of trusses, Analysis of plates, Solid of revolution. Dynamic analysis: Dynamic equations, Mass and damping matrices, Natural frequencies and modes, Damping, Model methods, Ritz vectors, Component mode synthesis, Direct integration techniques, Explicit and implicit methods, Analysis by responses spectra	
Heat Transfer and Fluid Mechanics Applications	**(07 Hours)**
Heat Transfer, Element formulation, Reduction -nonlinear problems, Transient thermal analysis, Acoustic frequencies and modes, fluid structure interaction problems, Plane incompressible and rotational flows.	
FEA Applications in Manufacturing	**(07 Hours)**

FE analysis of casting and Weldments solidification–special considerations, latent heat incorporation, FE analysis of metal forming and metal cutting.

(Total Lecture Hours: 45)

3. <u>Books Recommended:</u>

1	R. D. Cook, Concepts and Applications of Finite Element Analysis, 4th Edition, John Wiley and Sons, 2007
2	D. L. Logan, A first course in the finite element method, 5th Edition, Cenage Learning, 2012
3	J. N. Reddy, An Introduction to the Finite Element Method, 5th edition, McGraw Hill, 2017
4	T. R. Chandrupatla and A. D. Belagundu, Finite Elements in Engineering, 4th Edition, Pearson, 2015
5	O. C. Zienkiewicz, R. L. Taylor and J. Z. Zhu, The finite element method its basis and fundamentals, 7th edition, Elsevier, 2013

MEMF114	:	INDUSTRIAL TRIBOLOGY	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Analyze the lubrication and wear behaviour under different conditions
CO2	Identify and select suitable type of lubrication system for a given problem
CO3	Design and evaluate the performance parameters for sliding element bearings.
CO4	Design and evaluate the performance characteristics of rolling element bearings.
CO5	Select suitable strategy for instrumentation and inspection of selected feature/part
CO6	Compute relevant features in given system to ensure proper lubrication

2. Syllabus:

Surfaces, Friction and Wear	**(10 Hours)**
Topography of Surfaces, Surface features, Surface interaction, Theory of Friction, Sliding and Rolling Friction, Friction properties of metallic and non -metallic materials, Friction in extreme conditions, Wear, types of wear, Mechanism of wear, wear resistance materials, Surface treatment, Surface modifications, Surface coatings.	
Lubrication Theory	**(09 Hours)**
Lubricants and their physical properties lubricants standards, Lubrication Regimes in Hydrodynamic lubrication, Reynolds Equation, Thermal, inertia and turbulent effects, Elasto hydrodynamic (EHD) magneto hydrodynamic lubrication, Hydro static lubrication, Gas Lubrication, Solid lubrication.	
Design of Fluid Film Bearings	**(09 Hours)**
Design and performance analysis of thrust and journal bearings, Full, Partial, Fixed and pivoted journal bearings design, Lubricant flow and delivery, Power loss, Heat and temperature of steady and dynamically loaded journal bearings, Special bearings, Hydrostatic Bearing design.	
Rolling Element Bearings	**(09 Hours)**
Geometry and kinematics, Materials and manufacturing processes, Contact stresses, Hertzian stress equation, Load divisions, Stresses and deflection, Axial loads and rotational effects, Bearing life capacity and variable loads , ISO standards, Oil films and their effects, Rolling Bearings Failures	
Tribo Measurement and Instrumentation	**(08 Hours)**
Surface Topography measurements, Electron microscope, friction and wear measurements, Laser method, Instrumentation, International standards, Bearings performance measurements, Bearing vibration measurement	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Bharat Bhushan, Introduction to Tribology, Johan Wieley & Sons, New York, 2nd edition, 2013
2	Basu S. K., Sengupta S. N. , Ahuja B. B., " Fundamental of Tribology", PHI Learning Pvt, Ltd, New Delhi, 2009
3	G. Stachowiak and A. Batchelor. Engineering Tribology, ~~3r~~Elsevier Science, 3rd Edition, 2011
4	R. Gohar and H. Rahnejat. Fundamentals of Tribology, World Scientific Publishing Company, 3rd Edition, 2018
5	Harish Harani, Fundamentals of Engineering Tribology, Cambridge, 1st edition, 2017

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MEMF116	:	AUTOMATION IN MANUFACTURING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe importance of automations in manufacturing
CO2	Describe principles of automations and mechatronics in various manufacturing systems
CO3	Select suitable sensors, mechanism and microprocessor for an automation system
CO4	Explain and select suitable drives and systems for an automation system
CO5	Design and develop automated systems for manufacturing and material handling
CO6	Perform basic Programming's related to automation

2. Syllabus:

Introduction	**(03 Hours)**
Introduction: Importance of automation in the manufacturing industry. Use of mechatronics. Systems required.	
Design of Automated system	**(04 Hours)**
Design of an automated system: Building blocks of an automated system, working principle and examples	
Fabrication	**(06 Hours)**
Fabrication: Fabrication or selection of various components of an automated system. Specifications of various elements. Use of design data books and catalogues	
Sensors	**(05 Hours)**
Sensors: study of various sensors required in a typical automated system for manufacturing. Construction and principle of operation of sensors.	
Microprocessor technology	**(05 Hours)**
Microprocessor Technology: signal conditioning and data acquisition, use of microprocessor or micro controllers. Configurations. Working.	
Electrical Drives	**(03 Hours)**
Electrical drives – types, selection criteria, construction and operating principle.	
Mechanisms	**(04 Hours)**
Mechanisms: Ball screws, linear motion bearings, cams, systems controlled by camshafts	
Hydraulic Systems	**(06 Hours)**
Hydraulic systems: hydraulic power pack, pumps, valves, designing of hydraulic circuits.	
Pneumatic Systems	**(04 Hours)**
Pneumatic systems: configurations, compressors, valves, distribution and conditioning	
CNC Technology	**(05 Hours)**
CNC technology: basic elements, interpolators and programming.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Boltan, W., Mechatronics: electronic control systems in mechanical and electrical engineering, Longman, Singapore,1999
2	Gaonkar, R. S., Microprocessor architecture, programming,and applications with the 8085, Penram International Publishing (India), Delhi, 2000
3	Rothbart, H. A., CAM Design Handbook, McGraw-Hill, 2004.• Norton, R. L., Cam Design and Manufacturing Handbook, Industrial press Inc, 2002
4	Groover, M. P., Automation, Production Systems, and Computer-Integrated Manufacturing, Prentice Hall, 2001
5	Rao, P. N., CAD/CAM Principles and Applications, Tata McGraw Hill, New Delhi, 2010

MEMF118	:	COMPOSITES DESIGN AND MANUFACTURING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Relate the perspectives and applicability of composites over the other class of materials
CO2	Identify suitable fibers and reinforcements in composite for identified properties
CO3	Identify suitability of various manufacturing processes for composites
CO4	Categorize the allied issues of composites
CO5	Determine the macro-mechanical and micro-mechanical analysis of laminates
CO6	Elaborate the failure and design criteria for laminates

2. Syllabus:

Introduction	**(05 Hours)**
Introduction, classification, characteristics of composite materials, basic terminology, properties of constituents and composites, merits and demerits with other class of materials, applications, present statistics, future perspectives, related organizations/associations.	
Fundamentals of various fibers and reinforcements	**(07 Hours)**
Fiber terminology, glass fibers, aramid fibers, ultra-high molecular weight polyethylene (UHMWPE) fibers, carbon and graphite fibers, woven fabrics, reinforced mats, chopped fibers, prepreg. Polymer-matrix composites, metal-matrix composites, ceramic-matrix composites. Reinforcement forms –short fiber composites, textile composites, hybrid composite. Importance of curing, adhesive bonding and integrally cocured structures	
Manufacturing processes for composites	**(12 Hours)**
Classifications, open mold processes, closed mold processes, lay-up processes, vacuum-bag molding, pressure-bag molding, thermal expansion molding, autoclave molding, filament winding, pultrusion, pulforming, automated tape laying, compression molding, resin transfer molding, continuous laminating. Defects in manufacturing of composites, its causes and remedies. Manufacturing issues of small, big and complex components of composites – Case studies	
Allied issues of composites	**(06 Hours)**
Joining of composite materials, machining and cutting of composites, recycling of composites, material selection guidelines, nondestructive evaluation of polymer composite, interface- statistical distribution of fiber strength, standard mechanical tests for composite and constituents. Case studies for joining, cutting, recycling and testing of composites.	
Macromechanical and micromechanical analysis of laminates	**(07 Hours)**
Stress strain relationship for different type of materials, engineering constants for lamina, strength failure theories, hygrothermal stresses and strain. Concept of volume and weight fraction of fiber & matrix, density and void fraction, fiber packing. Evaluation of elastic modulies, ultimate strength of lamina, experimental evaluation using standard test methods, semi empirical models for prediction. Laminate – Code for laminate and	

stacking sequence, strength, stiffness and hygrothermal properties of laminate. Evaluation of elastic moduli, coefficient of thermal and moisture expansion for laminate	
Failure analysis and design of laminates	**(08 Hours)**
Failure criteria for laminate – Design of laminated composite structure and components, importance of constituents and their selection, stiffened structure, stiffener types, stiffener design, laminate joints, sandwich composite, environmental effects, inter laminar stresses, impact resistance, fracture resistance, fatigue resistance	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Gibson R.F., "Principles of composite material mechanics", McGraw-Hill Inc, 4^{th} edition, 2016
2	Jones R. M., "Mechanics of composite materials", CRC Press, 2^{nd} edition, 2015
3	Bhargava A.K. and Sharma C.P., "Mechanical behaviour and testing of materials", PHI publication, New Delhi, 1^{st} edition, 2011
4	Kaw A. K, "Mechanics of composite materials", Taylor and Francis, 2^{nd} edition, 2005
5	Harris B., "Engineering composite materials", Maney publication, 2^{nd} edition, 1999

MEMF120	:	SURFACE ENGINEERING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Decide the surface preparation methods suitable for different substrate materials
CO2	Demonstrate the ability to use the core concepts of engineering application in material degradation by corrosion, wear and its prevention
CO3	Describe the importance & role of surface modifications to achieve several technological properties
CO4	Explain importance of specific coating technique, characterization & its applications on specific engineering components
CO5	Select surface engineering technique for specific wear mechanisms and corrosion control
CO6	Propose suitable surface engineering technique to control material degradation

2. Syllabus:

Introduction	**(04 Hours)**
Introduction to surface engineering, Scope of surface engineering for different engineering materials, Surface Preparation methods such as Chemical, Electrochemical, Mechanical: Sand Blasting, Shot peening, Shot blasting, Hydro-blasting, Vapor Phase Degreasing etc., Coatings: Classification, Properties and applications of Various Coating.	
Wear	**(06 Hours)**
Adhesive wear, Abrasive and erosive wear, Wear induced by mechanical fatigue of the worn surface, Melting wear, fretting wear and diffusive wear, Analytical models of wear, Wear resistant materials, Fatigue, fracture and creep.	
Corrosion	**(06 Hours)**
Corrosion of metals in aqueous media: Electrochemistry and aqueous corrosion, Electrochemical corrosion of machinery and structures, Corrosion inhibitors, Materials factors in aqueous corrosion. Oxidative reactions of metals with oxygen, sulphur and other halogens.	
Discrete Coatings	**(06 Hours)**
Introduction, Coatings of organic compounds, Electrochemical coatings, Plasma and thermal spraying, plasma-transferred arc the D gun, Vacuum-based coating methods, Friction surfacing, weld overlays and explosive bonding, Advanced coating techniques.	
Integral Coatings and Modified Surface Layers	**(09 Hours)**
Introduction, Thermally or mechanically modified surface layers: Induction hardening, Laser and electron beam surface hardening, Shot-peening, Thermochemical methods of coating: Galvanization and hot-dipping, Carburizing, Carbonitriding, Nitriding, Nitrocarburizing & Boronizing, Advanced surface modification technologies: Plasma Nitriding and Plasma Carburization, Surface alloying by laser and electron beam, Ion implantation	

Characterization of Surface Coatings	(07 Hours)
Introduction, Measurement of surface roughness and coating thickness, Hardness and micro hardness analysis, Adhesively testing, Microstructural evaluation, Chemical analysis, Residual stress analysis, Corrosion testing.	
Control of Materials Degradation	**(07 Hours)**
Introduction, Methodology of analysing materials degradation, Selection of optimal surface engineering technology, Control of wear by surface engineering, Principles of coating selection for wear resistance, Selection of specific surface engineering techniques for specific wear mechanisms, Control of corrosion by surface engineering, Control of fatigue and fracture by surface engineering	

(Total Lecture Hours: 45)

3. Books Recommended:

1	T Burakowski and T. Wierzchon, Surface engineering of metals, CRC Press, 1st edition, 1998
2	A. W. Batchelor, L. N. Lam and M. Chandrasekaran, Materials degradation and its control by surface engineering, Imperial college press, 3rd edition, 2011
3	L. I. Tushinsky, I. Kovensky, A. Plokhov, V. Sindeyev, P. Reshedko, Coated Metal: Structure and Properties of Metal-Coating Compositions, Springer, Germany, 1st edition, 2002
4	M. Ohring, Materials Science of Thin Films, Academic Press, 2nd Edition, 2002
5	D. K. Dwivedi, Surface Engineering: Enhancing life of tribological components, Springer, 1st edition, 2018

MEMF122	:	QUALITY ENGINEERING AND MANAGEMENT	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain different concepts of quality, system reliability & maintenance and its application to the design and manufacturing activities
CO2	Apply statistical concepts and techniques for designing of products and process controls
CO3	Describe and apply reliability analysis concepts to selected applications
CO4	Describe and apply the factorial design and surface response method for experimental design.
CO5	Formulate, analyze, design and synthesize open-ended quality engineering problems using various statistical process control tools and quality management tool
CO6	Select and apply newer concepts and initiatives for quality improvement

2. Syllabus:

Introduction	**(03 Hours)**
Introduction to quality control and the quality system, Some philosophies and their impact on quality, Cost of quality, Quality audit.	
Statistical Quality Control	**(14 Hours)**
Statistical Concepts and Data analysis: Fundamentals of statistical concepts and techniques in quality control and improvement, Data analysis and sampling; Control Charts: Statistical Process Control using control charts, Control charts for attributes and variables. Process capability analysis: Concepts and procedures of Process capability. Acceptance Sampling: Acceptance sampling for attributes and variables	
Reliability Analysis	**(03 Hours)**
Reliability: Failure rate analysis, mean failure rate, mean time to failure, mean time between failure, Graphical representation of Fd, Z and R. Generalization in graphical form, integral form, Hazard models, systems reliability, availability, maintenance, overall equipment effectiveness, Total Productive Maintenance (TPM), Failure Mode and Effect Analysis (FMEA).	
Experimental Design	**(08 Hours)**
Experimental Design : Fundamentals of experimental Design, Single, Multi factor and 2^k factor experiments, Two level fractional factorial design, Response surface method. Quality loss function. Taguchi method: Taguchi method, Design of experiments using orthogonal array, Data analysis from Taguchi and Multi levelfactor design	
New Quality Concepts and Initiatives	**(12 Hours)**
New Quality Concepts and initiatives : Total Quality Management (TQM) and its	

techniques, New Seven Management Tools, and Industrial Case studies on Costs of Quality, Five S, kaizen, Quality Circles, Quality Function Deployment (QFD), Poka Yoke, Total Productive Maintenance (TPM), Lean Manufacturing, Six Sigma, Lean Six Sigma, etc. Quality Management through Software	
Quality Standards	**(03 Hours)**
Quality Standards and Business Excellence Models: Quality System Standards, ISO 9000, ISO 14000, various Quality Awards and case studies.	
World Class Manufacturing	**(02 Hour)**
Manufacturing Excellence World Class Manufacturing (WCM) – Modeland elements of WCM	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Amitra Amitava, Fundamentals of Quality Control and Improvement, 2nd Ed., PrenticeHall of India, 2011
2	K. Krishnaiah and P. Shahabudeen, Aplied Design of Experiments and Taguchi Methods, Prentice Hall of India, 2012
3	Dale H. Besterfield, Carol Besterfield-Michna, Mary Besterfield-Sacre, Glen H. Besterfield, Hemant Urdhwareshe, Rashmi Urdhwareshe, Total Quality Management, , Pearson Education, 2012
4	George W. Cobb, Introduction to Design and Analysis of Experiments, John Wiley & Sons, 2015
5	D.C. Montogomery, Design and Analysis of Experiments, John Wiley & Sons, 8th Edition, 2013

MEMF124	:	OPERATIONS RESEARCH	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Analyse a given system with constraints and express it in mathematical form
CO2	Formulate and solve mathematical problem using linear and non linear programing
CO3	Explain different queuing situations and find optimal solutions using applicable model
CO4	Analyse given network using PERT/CPM
CO5	Decide optimal solution under uncertainty using fuzzy and non fuzzy concepts
CO6	Simulate real life probabilistic situations using Monte Carlo simulation technique

2. Syllabus:

Linear Programming	**(10 Hours)**
Introduction, Linear Programming Problem (LPP), Standard Form of an LPP, Matrix Form of LPP. Solution of a LPP: The Simplex Method, Big M Method and Two-Phase Method. The Dual Simplex method. Duality in Linear Programming and Sensitivity Analysis. The Transportation and Transhipment Model and Sequencing Models.	
Integer Programming	**(04 Hours)**
Integer Programming Formulations. The Cutting Plane Algorithm. Branch and Bound Technique.	
Dynamic Programming	**(05 Hours)**
Characteristic of Dynamic Programming, Formulation, Applications of Dynamic Programming - Capital Budgeting Problem, Shortest Path Problem, Cargo Loading Problem, etc. Solution of Linear Programming Problem Through Dynamic Programming	
Non- Linear Programming	**(05 Hours)**
Introduction, Lagrangean Method, Kuhn-Tucker Conditions, Graphical Method, Quadratic Programming. Separable Programming. Geometric Programming	
Network Analysis	**(05 Hours)**
PERT and CPM Networks, Cost Analysis and Crashing the Network. Updating and Resource Scheduling	
Queuing Theory	**(06 Hours)**
Introduction, Terminologies of Queueing System, Classification of Queueing Models: Probabilistic and Deterministic. Assumptions and Limitations of Queueing Models	
Decision Analysis and Games	**(06 Hours)**
Decision Making Under Certainty – Analytical Hierarchy Process. Introduction to Fuzzy Numbers, Triangular and Trapezoidal Fuzzy Numbers, Membership Function, Fuzzy	

Decision Making. Terminologies of Game Theory, Game with Pure and Mixed Strategies. Dominance Property. Graphical Method and Linear Programming Approach for Game Theory	
Simulation	**(04 Hours)**
Simulation Concepts, Introduction, Advantages and Limitations of Simulation Techniques. Monte Carlo Simulation. Generation of Random Numbers. Applications of Simulation	

(Total Lecture Hours: 45)

3. Books Recommended:

1	P. K. Gupta and D. S. Hira, Operations Research, Third Edition, S. Chand and Company Ltd., New Delhi, 5th edition, 2005
2	J. K. Sharma, Operations Research –Theory and Applications, Macmillan Publishers India Ltd., 4th Edition, 2009
3	F. S. Hillier and G. J. Lieberman, Introduction to Operations Research- Concepts and Cases, Tata Mcgraw Hill, 9th Edition, 2010
4	N. D. Vora, Quantitative Techniques in Management, McGraw Hill Education (India) Private Limited, 4th Edition, 2014
5	H. Taha, Operations Research, Pearson, 10th edition, 2016

MEMF126	:	CONCURRENT ENGINEERING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Support the multi-disciplinary integrated product development teams and Plan and implement a new product development program
CO2	Apply appropriate concurrent engineering tools and techniques to design and develop environment-friendly products by leveraging both manufacturing cost and lifecycle cost
CO3	Determine the customer needs and ensure that the product design is robust and meets the professional standards with better quality
CO4	Design and develop the products with high reliability, maintainability and availability
CO5	Apply the information technology tools for collaborative product design and development.
CO6	Demonstrate the applications of concurrent design of structures, products and components.

2. Syllabus:

Introduction	**(07 Hours)**
Motivation, definition, and philosophy of Concurrent Engineering (CE); sequential and concurrent processes; Principles of CE; Organizing for CE; CE teams and team dynamics; Role of CAD/CAM/CAE/CIM and automation in CE; Managing product development projects; Decomposition of product development stages; Benefits of CE; Implementation issues of CE	
Concurrent Engineering Tools and Techniques	**(22 Hours)**
Design for manufacturing (DFM), Design for assembly (DFA); Factors influencing form design; Casting and machining considerations; Design for manufacturing and Assembly (DFMA) guidelines and examples; Lifecycle design of products with circular economy concept; Design for environment (DFE) with examples; Design for (-to-) cost; Design for X (DFX); Value engineering. Design for quality; Taguchi's methods for designing robust products; Design of Experiments (DOE) with examples; Design optimization; Quality function deployment (QFD) with examples. Design for reliability, maintainability and availability with examples; Failure modes and effects analysis (FMEA); Fault tree analysis (FTA); Rapid prototyping methods; Design simulation; Virtual and augmented reality environments for CE	
Role of Information Technology in Concurrent Engineering	**(08 Hours)**
Information technology (IT) components and functions; Artificial Intelligence for IT operations used for product design; Collaborative product development; Collaborative product commerce, Cloud IoT for CE	
Selected Applications of Concurrent Engineering	**(08 Hours)**

Design of aerospace and naval structures made of composite materials; Design of automotive components; Design of medical devices; Design of electronic products; Design of white goods parts

(Total Lecture Hours: 45)

3. Books Recommended:

1	B. Prasad. Concurrent Engineering Fundamentals I & II, Prentice Hall, New Jersey, 1995, 1996
2	I. Moustapha. Concurrent Engineering in Product Design and Development, New Age International, New Delhi, 2006
3	G. Boothroyd, P. Dewhurst, and W. Knight. Product Design for Manufacture and Assembly, 3rd Edition, Routledge, Boca Raton, 2010
4	J. R. Hartley. Concurrent Engineering: Shortening Lead Times, Raising Quality, and Lowering Costs, 4th Edition, Routledge, Boca Raton, 2017
5	K. T. Ulrich, S. D. Eppinger, and M. C. Yang. Product Design and Development, 7th Edition, McGraw Hill Education (India), Noida, 2020

MEMF128	:	NUMERICAL METHODS IN MANUFACTURING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain and compute errors in computer programing
CO2	Develop and analyse transcendental and algebraic equations
CO3	Apply optimality criterion on given real life problem
CO4	Develop regression models using different methods
CO5	Solve identified problems through given differential equations
CO6	Apply different equations and schemes to solve partial differentiation equations

2. Syllabus:

Error Analysis	**(07 Hours)**
Introduction to numerical analysis, Significant figures, round-off, precision and accuracy, approximate and true error, truncation error and Taylor series, machine epsilon, data uncertainties, error propagation, removal of errors in computer programming.	
Transcendental & Algebraic Equations	**(08 Hours)**
Bracketing & open Methods- Bisection, False Position, Newton- Raphson Method, Secant Method. Gauss Elimination, Gauss Jordon applications, Gauss Seidal, LU decomposition, Matrix Inversion	
Single variable optimization	**(08 Hours)**
Single variable optimization: Optimality Criterion, Bracketing methods - Exhaustive Search Method, Bounding Phase Method, Region Elimination Method - Interval Halving Method, Fibonacci Search Method, Golden Section Search Method, Point Estimation Method - Successive quadratic estimation method, Gradient based methods: - Newton Raphson Method, Bisection Method, Secant Method, Cubic Search Method, Root Finding Method using Optimization Technique	
Regression Analysis	**(08 Hours)**
Least Square Method, Linear Regression, Polynomial Regression, Fourier Regression, &Nonlinear Regression. Interpolation- Newton’s Forward and backward Interpolation, Newton’s Divided Difference Interpolation, Lagrange’s Interpolation, Gauss’s Central Difference Interpolation. Newton Cotes Integration formulas-Trapezoidal, Simpson, Romberg, Gaussian Quadrature, Numerical Differentiation-Finite Difference Method.	
Solution to Differential Equations	**(07 Hours)**
Types of Differential equations, Picard’s Series Method, Taylor Series Method, Euler’s Method, Modified Euler’s Method, Runge - Kutta Method, Predictor Corrector Method, Milnes Method, and Application to Initial & Boundary value Problems.	
Partial Differentiation Equations	**(07 Hours)**
Introduction to PDE Elliptic, Parabolic & Hyperbolic Equation. Finite Difference Schemes, Forward, Backward, Central Difference, Application to Laplace & Poisson’s Equation,	

Iterative & Relaxation Techniques, Laplacian Operator in Cartesian, polar and other coordinate systems. Solution of Parabolic Equations, Implicit & Explicit Schemes, Crank Nicholson, ADI scheme. Solution of Hyperbolic Equations.

(Total Lecture Hours: 45)

3. Books Recommended:

1	Steven C. Chapra, Reymond P. Canale, Numerical Methods for Engineers, Tata McGraw Hill Publications, 2010
2	E. Balagurusamy, Numerical Methods, Tata McGraw Hill Publications, 1999
3	E. Kreyszig, Advanced Engineering Mathematics, Tenth Ed., John Wiley and Sons, 2010
4	Kalyanmoy Deb, Optimization for Engineering Design - Algorithms and Examples, PHI Pvt. Ltd.
5	R. L. Burden and J. D. Faires, Numerical Analysis, 9th Edition (second Indian Reprint 2012),Brooks/Cole, 2011.

MEMF130	:	NON DESTRUCTIVE TESTING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Understand the basic concept of NDT and its industrial applications
CO2	Select appropriate NDT technique to identify given defect.
CO3	Identify internal flaw in the part and suggest measures to eliminate it
CO4	Analyse available data using modern tools and softwares
CO5	Introduce environmental friendly solutions to the industrial problem through NDT
CO6	Identify and overcome limitations of NDT technique through alternative techniques

2. Syllabus:

Introduction to NDT, Liquid Penetrant Test	**(07 Hours)**
Physical Principles, Procedure for penetrant testing, penetrant testing materials, Penetrant testing methods, sensitivity, Applications and limitations, typical examples.	
Ultrasonic Testing	**(07 Hours)**
Basic properties of sound beam, Ultrasonic transducers, Inspection methods, Techniques for normal beam inspection , Techniques for angle beam inspection, Flaw characterization techniques, Applications of ultrasonic testing , Advantages and limitations	
Thermography	**(06 Hours)**
Basic principles, Detectors and equipment, techniques, applications.	
Radiography	**(06 Hours)**
Basic principle, Electromagnetic radiation sources, radiographic imaging, Inspection techniques, applications, limitations, typical examples.	
Eddy Current Test	**(06 Hours)**
Principles, instrumentation for ECT, techniques, sensitivity, advanced eddy Current test methods, applications, limitations.	
Acoustic Emission	**(06 Hours)**
Principle of AET, Technique, instrumentation, sensitivity, applications, Acoustic emission technique for leak detection.	
Magnetic Particle Inspection	**(07 Hours)**
Principle of MPT, Procedure used for testing a component, sensitivity, limitations	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Peter J. Shull , Non-destructive Evaluation: Theory, Techniques and Applications, Marcel Dekkar, 1st edition, 2002
2	Ravi Prakash, Non Destructive Testing Techniques, New Age International Publishers, 1st edition, 2010
3	Sadashiva, Non Destructive Testing, Notion Press, 1st edition, 2021
4	ASM Metals Hand Book, Non Destructive Testing and Quality Control, Vol. 17, ASM, 1989.
5	Mix Paul, Introduction to NDT: A training guide, John Wiley and Sons, 2nd edition, 2005

MEMF132	:	INTELLIGENT MANUFACTURING SYSTEMS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the need and capability of AI based manufacturing system
CO2	Identify the characteristics and components of knowledge based expert systems
CO3	Apply probability and fuzzy logic for machine thinking
CO4	Apply the ANN modeling to identified manufacturing problem
CO5	Develop the knowledge based GT for selected automation system
CO6	Design an intelligent system for various manufacturing systems

2. Syllabus:

Concepts of Artificial Intelligence	**(09 Hours)**
Origin of Artificial Intelligence, Human and machine Intelligence, Branches of artificial intelligence, Programming in AI environment, Emergence of expert systems, Applications in Engineering and Manufacturing , Intelligent Manufacturing Systems – System components, System Architecture and Data Flow and System Operation	
Knowledge Based Systems/Expert Systems	**(12 Hours)**
Expert systems: Expert system process, characteristics and components of expert systems, Knowledge Acquisition: Knowledge acquisition phases, Methods of extracting knowledge from experts, Knowledge acquisition meetings, Group knowledge acquisition, Knowledge Representation: Characteristics of knowledge, Knowledge representation models, Concepts of knowledge sets and Reasoning models. Expert system justification and future directions for expert systems	
Machine Learning	**(10 Hours)**
Machine Learning – Concept, Artificial Neural Networks, Biological and Artificial Neuron, Types of Neural Networks, Applications in manufacturing, Use of probability and fuzzy logic for machine thinking	
Knowledge Based Group Technology	**(09 Hours)**
Group Technology: Models and Algorithms – Visual method, Coding method, Cluster analysis method , Knowledge based group technology – Group technology in automated manufacturing system, Structure of knowledge based system for group technology (KBSGT) – Database, Knowledge base, Clustering algorithm.	
Industrial Applications of AI	**(05 Hours)**
Intelligent system for design, equipment selection, scheduling, material selection, maintenance, facility planning and process control	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Michael Negnevitsky, Artificial Intelligence: A guide to Intelligent systems, Pearson, 3rd edition, 2020
2	A. B. Badiru, Expert Systems Applications in Engineering and Manufacturing, Prentice-Hall, New Jersey, 1992
3	Andrew Kussiak, Intelligent Manufacturing Systems, Prentice Hall, 1990
4	Kishan Mehrotra, Elements of Artificial Neural Network, Penram International Publishing Pvt Ltd; 2nd edition, 2009
5	Rajendra Akerkar, Knowledge based Systems, Jones & Bartlett, 1st edition, 2009

MEMF134	:	LOGISTICS AND SUPPLY CHAIN MANAGEMENT	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Understand the elements and functions of supply chain, role of drivers and demand forecasting
CO2	Describe the increasing significance of logistics and its impact on both costs and service
CO3	Build strategic framework to analyse supply chain of selected industries
CO4	Apply various techniques for managing inventory and transport network for selected situations
CO5	Apply suitable pricing and revenue management using information technology tools
CO6	Develop criteria to achieve improved performance by integrating and optimizing the logistics and supply-chain process

2. Syllabus:

Logistics and Supply Chain Management	**(04 Hours)**
Logistics Management-An Introduction, Key actors, Classification of Logistics Applications, Total logistics cost, Logistics to supply chain Management	
Building a Strategic Framework to Analyze Supply Chains	**(06 Hours)**
Historical evolution of supply chain, Understanding the supply chain, supply chain performance: achieving strategic fit, supply chain drivers and metrics and case studies.	
Designing the Supply Chain Network	**(07 Hours)**
Designing distribution networks and applications to e-business, network design in the supply chain, network design in an uncertain environment, and case studies	
Planning Demand and Supply in a Supply Chain	**(07 Hours)**
Demand forecasting strategy in a supply chain, aggregate planning in a supply chain, sales and operation planning: Planning supply and demand in a supply chain, and case studies	
Planning and Managing Inventories in a Supply Chain	**(08 Hours)**
Managing economies of scale in a supply chain: cycle inventory, managing uncertainty in a supply chain: safety inventory, determining the optimal level of product availability, and case studies	
Designing and Planning Transportation Networks	**(05 Hours)**
Transportation strategy in a Supply Chain and case studies	
Managing Cross-Functional Drivers in a Supply Chain	**(08 Hours)**
Sourcing decisions in a supply chain, pricing and revenue management in a supply chain, information technology in a supply chain, coordination in a supply chain, and case studies	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Sunil Chopra and Peter Meindel. Supply Chain Management: Strategy, Planning, and Operation, Pearson Education, 2010
2	Martin Christopher. Logistics and Supply Chain Management: Strategies for Reducing cost and Improving Services, Pearson Education, 2010
3	David Simchi Levi, Philip kaminsky, and Edith Simchi Levi. Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies. Irwin McGrawHill, 2000
4	Bowersox, Supply Chain Logistics Management, McGraw Hill Education, 4th edition, 2018
5	Raghuram and Rangaraj, Logistics and Supply chain management: Cases and concepts, Laxmi Publications, 1st edition, 2015

MEMF136	:	MICRO AND NANO MANUFACTURING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Classify and describe micro and nano manufacturing processes based on applications
CO2	Explain and select suitable micro machining/ micro forming/ MEMS processes based on given parameters and constraints
CO3	Explain and select suitable MEMS/NEMS technique for identified application.
CO4	Distinguish between the requirements for micro and nano manufacturing processes
CO5	Recommend a suitable nano- manufacturing process for a given application.
CO6	Propose suitable metrological technique for measuring micro and nano features.

2. Syllabus:

Introduction	**(03 Hours)**
Introduction to miniaturization and its needs, scaling laws, micro products and design considerations, classification, selection of micro machining processes, applications	
Micro Machining Processes	**(14 Hours)**
Evolution and Principle of micromachining, micro turning, micro milling, micro grinding, ultrasonic micro machining, abrasive jet micro machining, micro electro discharge machining, micro electro chemical machining, laser micro machining	
Micro Forming Processes	**(09 Hours)**
Micro scale plastic deformation, size effect, micro deep drawing, micro extrusion, micro punching, micro blanking, micro fabrication using bulk metallic glasses, flow induced defects.	
MEMS and NEMS Techniques	**(07 Hours)**
Classification, principle and working, photo lithography, chemical etching, LIGA, materials	
Introduction to Nano Manufacturing	**(08 Hours)**
Transition from nano technology to nano manufacturing; diamond turn machining; nano joining, nano soldering, nano welding, mechanical bonding, fastening; chemical vapor deposition, scanning tunnelling microscopy, nano lithography	
Abrasive Based Nano Finishing Processes	**(04 Hours)**
Abrasive flow finishing, chemo-mechanical polishing, magnetic abrasive finishing, magnetorheological finishing, magnetorheological abrasive flow finishing, magnetic float polishing, hybrid nanofinishing: chemo-mechanical magnetorheological finishing, electrochemical magnetic abrasive finishing	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Kei Cheng & Dehong Heo, Micro Cutting : Fundamentals and Applications, John Willey & Sons, 2013
2	V K Jain, Micromanufacturing Processes, CRC Press, 2013
3	Mark J. Jackson, Micromachining with Nanostructured Cutting Tools, Springer, 2013
4	N. Maluf and K. Williams, Introduction to MEMS Engineering, 2nd edition, Artechhouse, 2004
5	V K Jain, Nanofinishing Science and Technology, CRC Press, 2017

MEMF138	:	BIO INSPIRED MATERIALS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the need and applications of biomaterials
CO2	Identify biomaterials from desired properties for medical applications
CO3	Identify suitable metallic and ceramic materials for identified application
CO4	Identify the requirements for cardiovascular and orthopaedic implants
CO5	Select suitable material for tissue engineering and regeneration
CO6	Explain the effect of degradation of materials in biological environment

2. Syllabus:

Introduction to Biomaterials	**(05 Hours)**
Introduction to materials at the interface with biological sciences, Brief historical background, Requirement of biomaterials, classification of biomaterials, Class of materials used in the body, application of biomaterials, tissue engineering	
Desired properties in biomaterials for medical applications	**(04 Hours)**
Performance of biomaterials, Properties: Biocompatibility, nontoxic, mechanical properties (strength, wear, fatigue) Corrosion resistance, Osseointegration	
Permanent Metallic implant bio materials	**(05 Hours)**
Stainless steels, Co-Cr alloys, Ti based alloys, Ta based alloys. **Biodegradable Metals:** Mg based alloys, Zn based alloys, Fe based alloys, Limitation of biomaterials	
Ceramic Materials	**(07 Hours)**
Ceramic implant materials, alumina, yittria stabilized zirconia, hydroxyapatite glass ceramics carbons, restorable ceramics, composites. **Polymeric implant materials**: Polymers in biomedical use, polyethylene, polypropylene, acrylic polymer, hydrogels, polyurethans, polyamides, biodegradable synthetic polymers, silicon rubber, microorganisms in polymeric implants, polymer sterilization	
Dental Materials	**(06 Hours)**
Tooth composition and mechanical properties, impression materials, bones, liners, and varnishes for cavities, filling and restorative materials, oral implants, use of collagen in dentistry	
Cardiovascular and Orthopedic implants	**(06 Hours)**
Artificial heart, aorta and valves, geometry of circulation, vascular implants, cardiac pace makers, bone composition and properties, fracture healing, joint replacement, knee joint repair, bone regeneration with restorable materials	
Tissue Engineering Materials and Regeneration	**(06 Hours)**
Substrate scaffolds materials, cellular aspects, viability, stem cells, bladder regeneration, cartilage regeneration, skin regeneration, regeneration in cardiovascular system	

Degradation of Materials in the biological environment	(06 Hours)
Chemical and biochemical degradation of polymers, degradation effects on metals and ceramics, pathological classification of biomaterials	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Biomaterials Science: An introduction to Materials in Medicine, Edited by Ratner, Hoffman, Schoen and Lemons, Second Edition: Elsevier Academic Press, 2004
2	Biological Performance of Materials: Fundamentals of Biocompatibility, Jonathan Black, Marcel Dekker, Inc., New York and Basel, 1981
3	Park J.B. and Bronzino J.D., Biomaterials: Principals and Applications, CRC Press, 2003
4	Park J.B. and Lakes R.S., Biomaterials: An Introduction, 3rd edition, Springer press, 2007
5	Bhat, S.V., Biomaterials, 2nd edition, Narosa Publishing, 2007

MEMF140	:	DESIGN OF EXPERIMENTS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Formulate objective(s) and identify key factors in designing experiments for a given problem
CO2	Develop appropriate experimental design to conduct experiments for a given problem
CO3	Identify randomization, replication, blocking and degree of freedom based on given parameters and their levels
CO4	Analyze experimental data to derive valid conclusions
CO5	Optimize process conditions by developing empirical models using experimental data
CO6	Design robust products and processes using parameter design approach

2. Syllabus:

Fundamentals of Experimentation	**(05 Hours)**
Role of experimentation in rapid scientific progress, Historical perspective of experimental approaches, Steps in experimentation, Principles of experimentation	
Fundamentals of Design of Experiments	**(06 Hours)**
Basic principles – randomization, replication, blocking, degree of freedom, confounding, selection of quality characteristics, Signal to Noise ratio	
Simple Comparative Experiments	**(07 Hours)**
Basic concepts of probability and statistics, Comparison of two means and two variances, Comparison of multiple (more than two) means & ANOVA; understanding main effect and interaction effect	
Experimental Designs	**(07 Hours)**
Practical methodology for DoE, Factorial designs, fractional factorial designs, orthogonal arrays, standard orthogonal arrays & interaction tables, modifying the orthogonal arrays, selection of suitable orthogonal array design, analysis of experimental data	
Response Surface Methodology	**(10 Hours)**
Concept, linear model, steepest ascent, second order model, regression	
Taguchi's Parameter Design	**(10 Hours)**
Concept of robustness, noise factors, objective function & S/N ratios, inner-array and outer-array design, data analysis	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Ross P.J., Taguchi Techniques for Quality Engineering, McGraw-Hill Book Company, New York, 1st edition, 2008
2	Montgomery D.C, Design and Analysis of Experiments, John Wiley & Sons, New York, 7th Edition, 2008
3	Jiju Antony, Design of Experiments for Engineers and Scientists, Elsevier, 2nd edition, 2018
4	Colin Hardwick, Practical Design of Experiments, Create Space Independent Publisher, 1st edition, 2013
5	Madhav Phadke, Quality Engineering using Robust Design, Pearson Education, 1st edition, 1989

DEPARTMENT OF
MECHANICAL ENGINEERING

<u>M.TECH. (MECHANICAL ENGINEERING)</u>

SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY
Ichchhanath, Surat-395007, Gujarat, India
www.svnit.ac.in

Vision and Mission of Institute

Vision statement

To be one of the leading technical institutes disseminating globally acceptable education, effective industrial training and relevant research output.

Mission statement

To be a globally accepted center of excellence in technical education catalyzing absorption, innovation, diffusion and transfer of high technologies resulting in enhanced quality for all the stakeholders.

Vision and Mission of the Department

Vision statement

Perceives to be a globally accepted centre of quality technical education based on innovation and academic excellence.

Mission statement

Strives to disseminate technical knowledge to its undergraduate, post graduate and research scholars to meet intellectual, ethical and career challenges for sustainable growth of humanity, nation and global community.

PROGRAMME EDUCATIONAL OBJECTIVES (PEO)

The overall educational objective for **Master of Technology in Mechanical Engineering** is to educate students with excellent technical capabilities in the mechanical engineering discipline, who will be responsible citizens and continue their professional advancement through life-long learning.

As mechanical engineers with expertise in **Mechanical Engineering**, postgraduates are prepared with following educational objectives:

PEO1	**Knowledge:** Impart broad technical knowledge in mechanical engineering discipline with research attitude, problem solving techniques and hands-on skill.
PEO2	**Career:** Provide successful career with professional ethics and responsibilities as a leading or participating role in mechanical engineering, R & D organization, academia and other fields or to pursue Ph.D./higher studies.
PEO3	**Communication:** Communicate verbally, in writing or audio-visually with others.
PEO4	**Learning**: Encourage the importance of life-long learning skill and ware of contemporary global issues for the successful professional career through self-study, participation and professional development courses.

PROGRAM OUTCOMES (PO)

PO1	An ability to independently carry out research /investigation and development work to solve practical problems
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PSO1	Design, analyse and develop thermal, fluid and manufacturing systems using innovative research, modern tools and techniques.
PSO2	Demonstrate technical and professional skills to solve mechanical engineering problems for the benefits of industry and society.

COURSE STRUCTURE FOR
M.TECH.(MECHANICAL ENGINEERING)

SEMESTER –I

Code No.	Subject	L	T	P	Exam Scheme				Total	Credits	National hour of learning (Approx.)
					Theory		Tuto.	Pract.			
					Hrs.	Marks	Marks	Marks			
MEME101	**Core 1** Numerical Methods and Computations	3	1	0	3	100	25	-	125	4	70
MEME103	**Core 2** Computer Aided Engineering	3	0	2	3	100	-	50	150	4	85
MEME105	**Core 3** Advanced Thermal and Fluid Engineering	3	0	2	3	100	-	50	150	4	85
	Elective 1	3	0	0	3	100	-	-	100	3	55
MEME111	1. Electric Vehicles and Advanced I C Engines										
MEME113	2. Additive Manufacturing										
MEME115	3. Advanced Vibrations in Rotor Systems										
MEME117	4. Industrial Tribology										
MEME119	5. Power Plant Engineering										
	Elective 2	3	0	0	3	100	-	-	100	3	55
MEME121	1. Optimization Techniques										
MEME123	2. Industrial Robotics										
MEME125	3. Concurrent Engineering										
MEME127	4. Computational Fluid Dynamics										
MEME129	5. Design of Refrigeration and Air Conditioning Systems										
MEME131	6. Operation Planning and Control										
MEME107	Software Practice	0	0	4	-	-	-	50		2	70
MEME109	Laboratory Practice	0	0	4	-	-	-	50		2	70
METMV01 METMP01	Vocational training Professional Experience/Research Internship (Optional) (Only for PG diploma in Mechanical /Exit**)**	0	0	10						5	200
Total Credits										**22**	**490**

SEMESTER –II

<table>
<tr><th rowspan="3">Code No.</th><th rowspan="3">Subject</th><th rowspan="3">L</th><th rowspan="3">T</th><th rowspan="3">P</th><th colspan="5">Exam Scheme</th><th rowspan="3">Total</th><th rowspan="3">Credits</th><th rowspan="3">National hour of learning (Approx.)</th></tr>
<tr><th colspan="2">Theory</th><th>Tuto.</th><th>Pract.</th></tr>
<tr><th>Hrs.</th><th>Marks</th><th>Marks</th><th>Marks</th></tr>
<tr><td>MEME102</td><td>Core 4
Computer Integrated Manufacturing</td><td>3</td><td>1</td><td>2</td><td>3</td><td>100</td><td>25</td><td>50</td><td>175</td><td>5</td><td>100</td></tr>
<tr><td>MEME104</td><td>Core 5
Mechanical Design Analysis</td><td>3</td><td>1</td><td>0</td><td>3</td><td>100</td><td>25</td><td>0</td><td>125</td><td>4</td><td>70</td></tr>
<tr><td></td><td>Elective 3</td><td rowspan="6">3</td><td rowspan="6">0</td><td rowspan="6">0</td><td rowspan="6">3</td><td rowspan="6">100</td><td rowspan="6">-</td><td rowspan="6">00</td><td rowspan="6">100</td><td rowspan="6">3</td><td rowspan="6">55</td></tr>
<tr><td>MEME112</td><td>1. Renewable Energy Systems</td></tr>
<tr><td>MEME114</td><td>2. Design of Pressure Vessels</td></tr>
<tr><td>MEME116</td><td>3. Theory and Design of Cryogenic Systems</td></tr>
<tr><td>MEME118</td><td>4. Quality Engineering and Management</td></tr>
<tr><td>MEME120</td><td>5. Advanced Welding Technology</td></tr>
<tr><td></td><td>Elective 4</td><td rowspan="6">3</td><td rowspan="6">0</td><td rowspan="6">0</td><td rowspan="6">3</td><td rowspan="6">100</td><td rowspan="6">-</td><td rowspan="6">-</td><td rowspan="6">100</td><td rowspan="6">3</td><td rowspan="6">55</td></tr>
<tr><td>MEME122</td><td>1. Design of Experiments</td></tr>
<tr><td>MEME124</td><td>2. Design and Analysis of Composite Structures</td></tr>
<tr><td>MEME126</td><td>3. Combustion for Propulsion Systems</td></tr>
<tr><td>MEME128</td><td>4. Design of Heat Exchangers</td></tr>
<tr><td>MEME130</td><td>5. Non Destructive Testing</td></tr>
<tr><td></td><td>Institute Elective</td><td rowspan="6">3</td><td rowspan="6">0</td><td rowspan="6">0</td><td rowspan="6">3</td><td rowspan="6">100</td><td rowspan="6">-</td><td rowspan="6">-</td><td rowspan="6">100</td><td rowspan="6">3</td><td rowspan="6">55</td></tr>
<tr><td>MEME172</td><td>1. Industrial Safety</td></tr>
<tr><td>MEME174</td><td>2. Intelligent Manufacturing Systems</td></tr>
<tr><td>MEME176</td><td>3. Energy Conservation, Management and Audit</td></tr>
<tr><td>MEME178</td><td>4. Energy and Buildings</td></tr>
<tr><td>MEME180</td><td>5. Instrumentation and Experimental Methods</td></tr>
<tr><td>MEME106</td><td>Mini Project</td><td>0</td><td>0</td><td>4</td><td>2</td><td>-</td><td>-</td><td>50</td><td>50</td><td>2</td><td>70</td></tr>
<tr><td>METMV02
METMP02</td><td>Vocational training Professional Experience/Research Internship (Optional) (Only for PG diploma in Mechanical /Exit)</td><td>0</td><td>0</td><td>10</td><td></td><td></td><td></td><td></td><td></td><td>5</td><td>200</td></tr>
<tr><td colspan="10">Total credits</td><td>20</td><td>405</td></tr>
</table>

SEMESTER –III

Code No.	Subject	L	T	P	Exam Scheme				Total	Credits	National hour of learning (Approx.)
					Theory		Tuto.	Pract.			
					Hrs.	Marks	Marks	Marks			
	MOOC Course-I *	-	-	-						3/4	70/80
	MOOC Course-II *	-	-	-						3/4	70/80
MEME295	Dissertation Preliminaries	-	-	-	-	-	-	350	350	14	560
Total Credits										**20-22**	**700-720**

SEMESTER -IV

Code No.	Subject	L	T	P	Exam Scheme				Total	Credits	National hour of learning (Approx.)
					Theory		Tuto.	Pract.			
					Hrs.	Marks	Marks	Marks			
MEME296	Dissertation	-	-	-	-	-	-	600	600	20	800
Total Credits										**20**	**800**

Total Credits: 22+20+20-22+20 = 82-84

<u>CREDIT MATRIX</u>

Category	Credits to be earned				
	Sem- I	**Sem - II**	**Sem- III**	**Sem - IV**	**Total**
Core Courses	12	09	-	-	21
Elective Courses	06	09	-	-	15
Laboratory Practice	02	––	-	-	02
Laboratory Practice	02	–	-	-	02
MOOC Courses	-	-	06-08	-	06-08
Mini Project	--	02	--	--	02
Dissertation	-	-	14	20	34
Total Credits	22	20	20-22	20	**82-84**

MEME101	**:**	**NUMERICAL METHODS AND COMPUTATIONS**	**L**	**T**	**P**	**Credits**
			3	**1**	**0**	**04**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the fundamental of numerical methods and applications in engineering problems
CO2	Implement solution procedures for solving linear and non-linear algebraic equations
CO3	Learn how to solve definite integrals by using cubic spline, Romberg and initial value problems and boundary value problems numerically
CO4	Solve ordinary differential equations (odes), and partial differential equations (PDEs) on a computer
CO5	Acquire working knowledge of computational complexity, accuracy, stability, and errors in solution procedures
CO6	Solve one-dimensional optimization problems using optimization algorithm

2. Syllabus:

1. Introduction	**(03 Hours)**
Introduction to Computer Aided Engineering Analysis, Measuring Errors, Sources of Error, Binary Representation of numbers, Floating Point Representation, Propagation of Errors, Taylor Theorem Revisit	
2. Differentiation	**(04 Hours)**
Primer on Differential Calculus, Differentiation of Continuous Functions, Differentiation of Discrete Functions	
3. Nonlinear Equations	**(04 Hours)**
Solving Quadratic Equations Exactly, Solving Cubic Equations Exactly, Bisection Method, Newton-Raphson Method, Secant Method, False-Position Method	
4. Simultaneous Linear Equations	**(05 Hours)**
Introduction to Matrix Algebra, Systems of Equations, Gaussian Elimination, Gauss-Seidel Method, LU Decomposition, Gauss-Seidel Method, Adequacy of Solutions, Eigenvalues and Eigenvectors, Cholesky and LDLT Method	
5. Interpolation	**(04 Hours)**
Background of Interpolation, Direct Method, Newton’s Divided Difference Method, Lagrange Method, Spline Method	
6. Regression	**(05 Hours)**
Primer on Statistical Terminology, Introduction to Regression, Linear Regression, Nonlinear Regression, Adequacy of Regression Models	
7. Integration	**(05 Hours)**
Primer on Integral Calculus, Trapezoidal Rule, Simpson’s 1/3rd Rule, Romberg Integration, Gauss-Quadrature Rule, Discrete Data Integration, Improper Integration, Simpson’s 3/8 Rule	

8.	**Ordinary Differential Equations**	**(05 Hours)**
	Primer on Ordinary Differential Equations, Initial Value Problems, Euler's Methods, Runge-Kutta methods, Predictor - Corrector Method, Higher Order/Coupled ODEs, Boundary Value Problems, Shooting Method, Finite Difference Method	
9.	**Partial Differential Equations**	**(05 Hours)**
	Introduction to Partial Differential Equations, Parabolic Partial Differential Equations, Elliptic Partial Differential Equations	
10.	**Optimization**	**(05 Hours)**
	Golden Section Search Method, Newton's Method, Multidimensional Direct Search Method, Multidimensional Gradient Method, Simplex Method	

(Total Lecture Hours: 45)

3. Books Recommended:

1	S.C. Chapra, R.P. Canale, "Numerical Methods for Engineers", 7th edition, McGraw hill, 2015.
2	B.S. Grewal, "Numerical Methods in Engineering & Science", 11th edition, Khanna Publication, 2013.
3	W. Cheney, D. Kincaid, "Numerical Mathematics and Computing", 7th edition, Cengage, 2013
4	C. Gerald, P. Wheatley, "Applied Numerical Analysis", 7th edition, Pearson Education India, 2007.
5	E. Isaacson, H. B. Keller, "Analysis of Numerical Methods", Dover Publications, 1994

MEME103	**:**	**COMPUTER AIDED ENGINEERING**	**L**	**T**	**P**	**Credits**
			3	**0**	**2**	**04**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the concept of computer graphics, drafting, and modelling using different commands and graphical user interface
CO2	Apply the concept of transformation for generating different positions of given problem with defined geometry
CO3	Create 3D models assemblies and generative drawings of a given engineering part or product
CO4	Apply the knowledge of programming for complex shape required in engineering for drafting or modelling
CO5	Determine the coordinates of space curves and parametric curves required for generating features in CAD models
CO6	Apply the knowledge of approximate methods (FDM/FEM) to solve engineering problems and to analyze status of variable in domain through various interpolation approaches.

2. Syllabus:

Computer Graphics:	**(15 Hours)**
Basics of Computer Aided Design, Introduction to Computer graphics, CAD/CAM hardware, 2D & 3D Transformations. **Plane Curves and Space Curves:** Parametric non parametric curves – cubic splines – Bezier curves, B-spline curves.	
3-D Modeling:	**(15 Hours)**
Solid modeling, modeling approaches-coordinate system-basic features-viewing/visualization-hidden line removal. Introduction to Computer Aided Drafting and modeling using software approach. Programming techniques in drafting/ modeling.	
Numerical Analysis:	**(15 Hours)**
Finite Difference Method and Finite Element Method-direct approach, variational approach and weighted residual approach, iso-parametric elements, interpolation functions elemental matrix, assembly and boundary conditions, condensation, solution algorithms. Application of FEM in elastic plane stress, plane strain and anisymmetric problem. Application of FEM to lubrication and thermal problems.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	I. Zeid, Mastering CAD/CAM, Tata Mcgraw-Hill Education Private Limited, 2005.
2	A.D. Belegundu and T.R. Chandrupatla, Finite Elements in Engineering, Prentice Hall of India Private Ltd., 1997.
3	J.N. Reddy, An Introduction to the Finite Element Method, Tata Mcgraw-Hill Education Private Limited, 2005.
4	D. Rogers, J.A. Adams , Mathematical Elements for Computer Graphics, Tata Mcgraw Hill Education Private Limited, 2002.
5	C. S. Krishnamoorthy, S. Rajeev, A. Rajaraman, Computer Aided Design: Software and Analytical Tools, Second Edition Narosa Publishing House, 2009.

List of Practicals

1. Sketching of conceptual design through Drafting of a given engineering component
2. Programming In drafting for a given sketch or mechanical component
3. Creating a 3d model of mechanical components exploring various features of CAD tools.
4. Developing relational sketches and model for designing mechanical components.
5. Creating communication drawing using generative approach for manufacturing requirement of given engineering part or product.
6. Creating assemblies for designing digital product through CAD software.
7. Creating a digital models and surfaces of non-geometric nature through parametric curves.
8. Creating presentation animation for digital communication of engineering products.
9. Solving linear problem for a given engineering problems using 1D approach using FEM software
10. Solving linear problem for a given engineering problems using, 2D approach using FEM software
11. Solving linear problem for a given engineering problems using 3D approach using FEM software
12. Demonstrating FEM software for Nonlinear problems using FEM software
13. Solving given engineering problem using FDM by computation approach.

MEME105	:	ADVANCED THERMAL AND FLUID ENGINEERING	L	T	P	Credits
			3	0	2	04

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the concepts of availability and irreversibility and conduct exergy analysis of thermodynamic systems
CO2	Evaluate the performance of vapor power cycles, gas power cycles, combined vapor and gas power cycles, and refrigeration cycles
CO3	Solve complex heat transfer problems of conduction / convection / radiation
CO4	Solve complex heat transfer problems of boiling and condensation
CO5	Apply governing equations to solve different fluid flow problems
CO6	Explain fluid flow measurements and flow visualization techniques

2. Syllabus:

Thermodynamics:	(15 hours)
Fundamental laws of thermodynamics, availability and irreversibility, second-law efficiency, exergy change of a system, exergy transfer by heat, work, and mass flow, exergy balance for closed systems and control volumes. Power cycles, Rankine cycle with reheating and regeneration, super-critical Rankine cycle, ultra-super-critical technology, Kalina cycle, Brayton cycle with intercooling, reheating, and regeneration, Otto, diesel, and dual cycles for internal combustion engines, Stirling cycle, Ericsson cycle, second law analysis of power cycles, Combined gas and vapor power cycles; Refrigeration cycles, Innovative vapor compression refrigeration systems.	
Heat Transfer	**(15Hours)**
Modes of heat transfer; general heat conduction equation in Cartesian, cylindrical, and spherical coordinates, steady-state heat conduction considering multiple dimensions, numerical methods of analysis, unsteady state heat conduction, heat flow in a semi-infinite solid; empirical and practical relations for forced convection heat transfer, natural convection in internal and external configurations, combined free and forced convection; radiation heat transfer, black and gray body radiation, intensity of radiation and Lambert's cosine law, radiative transport equation for bulk radiation; boiling and condensation heat transfer, heat pipe; methods to improve the performance of heat exchangers.	
Fluid Flow:	**(15 hours)**
Reynolds transport theorem, Navier-Stokes equation, analytical solutions to simple flows, Couette flow, Poiseuille flow, concepts of lift and drag, flow separation and drag, boundary layer theory, boundary layer flow over a flat plate and with non-zero pressure gradient, free shear flow, characteristics of turbulent flows, Reynolds Averaged Navier Stokes (RANS) equations, compressible flow through convergent and Laval nozzles, normal and oblique shock waves, micro-flows, fluid flow measurements and flow visualization techniques.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Y. A. Cengel, M. A. Boles, and M. Kanoglu. Thermodynamics - An Engineering Approach, 9th Edition, McGraw Hill, 2019.
2	R. K. Rajput. Thermal Engineering, 11th Edition, Laxmi Publications, 2020
3	J. P. Holman and S. Bhattacharya. Heat Transfer, 10th Edition, McGraw Hill, 2017.
4	Y. A. Cengel and J. M. Cimbala. Fluid Mechanics: Fundamentals and Applications, 4th Edition, McGraw Hill, 2018
5	F. M. White and H. Xue. Fluid Mechanics, 9th Edition, McGraw Hill, 2021

4. List of Practicals (Any 08)

1. Experiments to characterize the pyrolysis behavior of selected biomass fuels.
2. To determine the yield from gasification of different biomass.
3. Preparation and performance analysis of biofuels on IC engines.
4. Experimental investigation of thermal performance of tube finned heat exchanger
5. Calculation of effectiveness and efficiency of the fin for different heat fluxes.
6. Flow & heat transfer simulation for various engineering applications.
7. Two-phase flow experiments.
8. Comparison of flow measuring instruments - measurement of static and dynamic characteristics of instruments.
9. Performance Test on Cascade Refrigeration System
10. Performance Tests on Internal Combustion Engines
11. Wind Tunnel Test
12. Pump Testing for determination of losses
13. Heat pipe experiment

MEME111	:	**ELECTRIC VEHICLES AND ADVANCED I C ENGINES**	**L**	**T**	**P**	**Credits**
			3	**0**	**0**	**03**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Compare the general specifications of various commercially available vehicle
CO2	Apply material and design considerations for various engine components
CO3	Evaluate effects of various parameters including use of alternate fuels on normal and abnormal combustion, emission and performance in CI and SI Engines
CO4	Compare basic layout and structure of EV and I C Engines
CO5	Estimate battery and motor sizing for various applications in two, three and four wheeler segment
CO6	Analyze Bus Rapid Transit Systems

2. Syllabus:

Introduction to I C Engines:	**(03 hours)**
Historical Perspective, General Specifications of Engines used in various Two, Three and Four Wheelers. Air Standard Thermodynamic Cycles for I C Engines and its comparison with Fuel Air and Actual Cycle, Thermodynamic properties of working fluid.	
Material and Design Consideration for Engine Components	**(04 hours)**
Piston, Cylinder, Piston Rings, Connecting Rod, Cam Shafts, Crank Shafts etc.	
Gas Exchange Process:	**(04 hours)**
Flow through valves, Analysis of suction and Exhaust Processes	
Combustion in SI and CI Engines:	**(06 hours)**
Combustion Phenomenon in SI and CI Engines, Normal and Abnormal combustion in SI and CI Engines, modelling combustion process in SI engines, Advanced mode combustion like HCCI, PCCI, AFCI, RCCI etc.	
Alternate Fuelled Engines :	**(03 hours)**
Producer Gas, Biogas and Biodiesel Fuelled Engines	
Engine Emission:	**(06 hours)**
Introduction to air pollution from SI and CI Engines, Photochemical smog, primary and secondary pollutants, Formation of NO and NO2 in SI and CI Engines, Mechanism of Particulate Matter formation, Composition of Particulates, soot structure, soot formation, Measurement of emission, instrumentation for HC, CO, NOx and PM, EGR and Diesel Particulate Filter.	
Introduction to Electric Vehicles :	**(04 hours)**

Limitations of Internal Combustion Engines as Prime Mover, History of EV and EV Systems, Structure of Electric Vehicle covering basic Components, General Layout, Govt. policies on EV and its impact on automotive sector	
EV Power Train:	**(12 hours)**
Basic components like Battery, DC-AC Converters, Electric Motors, DC-DC Converters, Transmissions and ECUs. Battery and Motor Selection, Calculations for Motor and battery sizing for EV for Two, Three and Four Wheeler Applications, Thermal Management of Battery, Initial acceleration, rated vehicle velocity, maximum velocity and maximum gradeability of EV, Basic architecture of EV Drive Train.	
Urban Transport :	**(03 hours)**
Urban Bus Specifications, Bus Rapid Transit Systems	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Hiroshi Yamagata, The Science and Technology of Materials in Automotive Engine, CRC Press Inc.,2005
2	John B Heywood, Internal Combustion Engines Fundamentals. McGraw Hill (Indian Edition) 2017.
3	V Ganesan, Internal Combustion Engines. 4th Edition. Tata Mc Graw Hill Edition
4	Mehrdad Ehsani, Yimin Gao, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles., 2nd edition, 2009.
5	Joseph Kent, Handbook of Electric Vehicles, Clanrye International, 2015

MEME113	:	ADDITIVE MANUFACTURING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Classify additive manufacturing processes and explain generic steps in additive manufacturing.
CO2	Explain principle, and mechanism of solid based, liquid based and powder based additive manufacturing processes.
CO3	Select a suitable additive manufacturing process for a given material and application.
CO4	Identify software related issues in additive manufacturing; and post processing aspects including defects and part quality.
CO5	Design and optimize a given part following guidelines and rules for part building.
CO6	Elaborate state of art in additive manufacturing.

2 Syllabus:

Introduction	**(06 Hours)**
Definition, classification, stages of generic additive manufacturing process, benefits, applications, process selection, evaluation, benchmarking, future growth and opportunities	
Solid Based Processes	**(06 hours)**
Basic principle and working of Fused Deposition Modelling process, liquefaction, solidification and bonding, bio extrusion, Laminated Object Manufacturing process, Multi jet process, typical materials and applications	
Liquid Based Processes	**(06 Hours)**
Photo polymerization, principle and working of stereo lithography apparatus, scanning techniques, curing processes, typical materials and applications	
Powder Based Processes	**(06 Hours)**
Powder fusion mechanism, powder handling and recycling, Principle and working of Selective Laser Sintering, Laser Engineering Net Shaping process, Electron Beam Melting, process parameters, typical materials and applications, safety considerations	
Additive Manufacturing Data Formats, Pre-processing & Post processing	**(08 Hours)**
Additive manufacturing file formats, Defects and Issues in Data Formats; Pre-processing – Part orientation and support structure generation, Model Slicing, Contour Generation, Tool Path Generation, Build File preparation, Machine Set-up; Post Processing – Product quality evaluation, support structure removal, Improvement of finish, geometry and aesthetics.	

Design For Additive Manufacturing	**(08 Hours)**
Core concepts and objectives, Principles of design for manufacturing and assembly, Constraint approach to design for additive manufacturing: Guidelines and rules for part building, Topology optimization and generative design, exploring design freedom, design tools.	
Recent Trends in Additive Manufacturing	**(05 Hours)**
Composite 3D printing, Bio 3D printing of tissues and organs, Clay and Concrete 3D printing, 3D food printing, 3D printing in space, 4D printing	

(Total Lecture Hours: 45)

3. Books Recommended:

1	I. Gibson, D. Rosen, B. Stucker, Additive Manufacturing Technologies, Springer Publisher, 2nd Edition, 2015
2	C. K. Chua, K. F. Leong, C. S. Lim, Rapid Prototyping – Principles and Applications, World Scientific, 3rd Edition, 2010.
3	C. P. Paul, A. N. Anoop, Additive Manufacturing – Principles, Technologies and Applications, Mc Graw Hill Education (I) Pvt. Ltd., 1st edition, 2021.
4	A. Bandyopadhyay and S. Bose, Additive Manufacturing, CRC Press, 2nd edition, 2015.
5	Diegel, Olaf, Axel Nordin, and Damien Motte. A Practical Guide to Design for Additive Manufacturing. Springer Singapore, 1st edition, 2019

MEME115	:	ADVANCED VIBRATIONS IN ROTOR SYSTEMS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe and Analyze free and forced vibration in machinery.
CO2	Explain Damped and Undamped vibration stability concepts.
CO3	Analyze and solve Non-Linear vibration problems.
CO4	Describe & Examine vibration analysis problems in rotor systems with non-linear effects included.
CO5	Illustrate the utility of instrumentation and terminology used in signal analysis for fault detection in rotating machinery.
CO6	Analyse various plots used in condition monitoring of rotors to predict rotor faults.

2. Syllabus:

Introduction	**(05 hours)**
Free and forced vibrations with and without damping, transient vibrations, Laplace transform formulation.	
Isolation and Stability Criterion	**(10 hours)**
Vibration isolation and transmissibility, undamped vibration absorbers, self-exited vibrations, criterion of stability, effect of friction on stability.	
Nonlinear Vibration	**(10 hours)**
Free vibration with nonlinear spring force or nonlinear damping, phase plane, energy curves, Lienard's graphical construction, methods of isoclines, random vibration, power spectral density, bandwidth in vibration, numerical methods for vibration analysis, vibration of continuous systems, Euler equation for beams, effect of rotary inertia and shear deformation.	
Vibration Analysis of Rotors	**(10 hours)**
Transverse vibrations single, two and three rotor systems, critical speeds of shafts, torsional vibrations of rotors: one, two and three disc rotor system, frequency of torsional vibration systems, coupling of torsional and bending vibrations due to pretwist and eccentricity, rotor faults, forward and backward rotor whirl model, variable elasticity effects in rotating systems, flow induced vibration in rotating systems, Newkirk effect, stresses in rotating disc and blade, disc of uniform strength, thermal stresses.	

Diagnostic Techniques	(10 hours)
Introduction to diagnostic maintenance and instrumentation in machinery vibration, amplitude, frequency and phase characteristics, signature analysis-trend plot, time domain plot, frequency-domain plot, FFT, spectrum plot, fault detection transducers, artificial intelligence techniques applied to vibration analysis.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	S. S. Rao. Mechanical Vibrations, 4th Edition, Pearson Education, 2007.
2	L. Meirovitch. Fundamentals of Vibrations, McGraw Hill, 1st edition, 2001.
3	E. Krämer. Dynamics of Rotors and Foundations, Springer-Verlag, New York, 1993.
4	R. Subbiah and J. E. Littleton. Rotor and Structural Dynamics of Turbomachinery-A Practical, 1st edition, 2018
5	P. Luciano Gatti. Advanced Mechanical Vibrations: Physics, Mathematics and Applications. CRC Press; 1st edition 2020

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MEME117	:	INDUSTRIAL TRIBOLOGY	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Analyze the lubrication and wear behaviour under different conditions
CO2	Identify and select suitable type of lubrication system for a given problem
CO3	Design and evaluate the performance parameters for sliding element bearings.
CO4	Design and evaluate the performance characteristics of rolling element bearings.
CO5	Select suitable strategy for instrumentation and inspection of selected feature/part
CO6	Compute relevant features in given system to ensure proper lubrication

2. Syllabus:

1.	**Surfaces, Friction and Wear**	**(10 Hours)**
	Topography of Surfaces, Surface features, Surface interaction, Theory of Friction, Sliding and Rolling Friction, Friction properties of metallic and non -metallic materials, Friction in extreme conditions, Wear, types of wear, Mechanism of wear, wear resistance materials, Surface treatment, Surface modifications, Surface coatings.	
2.	**Lubrication Theory**	**(08 Hours)**
	Lubricants and their physical properties lubricants standards, Lubrication Regimes in Hydrodynamic lubrication, Reynolds Equation, Thermal, inertia and turbulent effects, Elasto hydrodynamic (EHD) magneto hydrodynamic lubrication, Hydro static lubrication, Gas Lubrication, Solid lubrication.	
3.	**Design of Fluid Film Bearings**	**(09 Hours)**
	Design and performance analysis of thrust and journal bearings, Full, Partial, Fixed and pivoted journal bearings design, Lubricant flow and delivery, Power loss, Heat and temperature of steady and dynamically loaded journal bearings, Special bearings, Hydrostatic Bearing design.	
4.	**Rolling Element Bearings**	**(09 Hours)**

	Geometry and kinematics, Materials and manufacturing processes, Contact stresses, Hertzian stress equation, Load divisions, Stresses and deflection, Axial loads and rotational effects, Bearing life capacity and variable loads , ISO standards, Oil films and their effects, Rolling Bearings Failures.	
5.	**Tribo Measurement and Instrumentation**	**(09 Hours)**
	Surface Topography measurements, Electron microscope, friction and wear measurements, Laser method, Instrumentation, International standards, Bearings performance measurements, Bearing vibration measurement.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Bharat Bhushan, Introduction to Tribology, Johan Wieley& Sons, New York, 2nd edition, 2012
2	Basu S. K., Sengupta S. N. , Ahuja B. B., " Fundamental of Tribology", PHI Learning Pvt, Ltd, New Delhi, 2009
3	G. Stachowiak and A. Batchelor. Engineering Tribology, Elsevier Science, 4th edition, 2014
4	R. Gohar and H. Rahnejat. Fundamentals of Tribology, World Scientific Publishing Company, 3rd Edition, 2018
5	Harish Harani, Fundamentals of Engineering Tribology, Cambridge, 1st edition, 2017

MEME119	**:**	**POWER PLANT ENGINEERING**	**L**	**T**	**P**	**Credits**
			3	**0**	**0**	**03**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe the mechanism of various types of steam boilers and steam turbines.
CO2	Design and Analyze boiler accessories, condenser, feed water heater, cooling tower.
CO3	Assess combustion mechanism, combustion equipment, heat balance sheet of boiler plant.
CO4	Describe the mechanism of non-conventional power generation and direct energy conversion.
CO5	Analyze the Gas turbine power plant to improve overall performance.
CO6	Evaluate power plant economy and evaluate steam power plant to improve performance.

2. Syllabus:

Introduction to Power Plants	**(04 hours)**
Introduction to sources of energy for power generation. Site selection criteria for power plants, Principal types of power plants, Present status of power generation in India, General layouts of various types of power plants	
Steam Generators and Accessories	**(10 hours)**
Classification of boilers, Description of boilers – Radiant type natural circulation boiler, High pressure forced circulation boilers, heat absorption in boilers, Circulations of down comers and riser, steam drum and its internals, supercritical steam generators, Fluidized bed combustion boilers – Bubbling and circulatory, Economizers, Air preheaters, Superheaters, De-superheaters, firing methods, Reheaters, fabric filters and bag house collector, electrostatic precipitators, feed water heaters, deaerator, ash handling system, Waste Heat Recovery Steam Generators (WHRSG), Numerical based on above theories	
Thermal Power Plants	**(08 hours)**
Fuels and combustion, Review of power cycles, coal fired power plant site selection, boiler, turbine, condensing plant and circulating water system, water treatment, fuel handling and fuel firing, ash handling and dust collection, Principles of co-generation, technical options for cogeneration.	

Environmental Aspects of Power Station	(05 hours)
Different pollutants due to thermal power plant and their effects on human health. Environment control of various pollutants such as particulate matter, oxides of Sulphur, oxides of nitrogen etc. Effluents from power plants, social and economic issues of power plants	
Gas Turbine Power Plant	**(06 hours)**
General features and characteristics and their application power plants, Analysis of different cycles, components of gas turbine power plants, governing system of gas turbine plant, advantages of G. T. plant, Gas and steam turbines, combined cycles – Thermodynamic analysis for optimum design, Numerical based on above theories	
Solar and Wind based Power Generation	**(06 hours)**
Energy available from the Sun and wind. General layout of solar thermal and solar photovoltaic power plants, Plant sizing for solar and wind, site selection criteria for wind and solar power plants, State and central Government policies for solar and wind power generation.	
Economics of Power Generation	**(06 hours)**
Introduction, Load-Duration curves, Load factor, Capacity factor, Reserve factor, demand factor, Diversity factor, plant use factor, base load plant, peak load plant, power plant economics – electricity cost, fixed costs and depreciation, Present-Worth Concept, Incremental Heat Rate, Effect of Load Factor on Cost per kWh, Numerical based on above theories	

(Total Lecture Hours: 45)

3. Books Recommended:

1	P. K. Nag, Power plant engineering, McGraw Hill Education, New Delhi, 2014
2	M. M. Ei-Wakil, Power plant Technology, McGraw Hill Education, New Delhi, 1st edition, 2017
3	R. K. Hegde, Power plant engineering, Pearson India Education, New Delhi, 2015
4	Arora & Domkundwar, Power plant engineering, Dhanpat Rai& Sons, New Delhi, 8th edition 2016
5	P. C. Sharma, Power Plant Engineering, S.K. Kataria & Sons, New Delhi, 3rd edition, 2010.

MEME121	:	OPTIMIZATION TECHNIQUES	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

1.	Explain the concept of optimization, related terms and formulate mathematical models for practical problems based on the information provided.
2.	Apply linear programming to solve real life linear programming problems
3.	solve transportation and transhipment problems, travelling salesman problem and integer programming
4.	determine solutions that will be deployed in real world situations after conducting sensitivity and post optimality analysis
5.	apply classical methods to solve nonlinear programming problems
6.	Apply evolutionary algorithms to solve complex engineering problems where classical methods are not suitable.

2. Syllabus:

Introduction	**(04 hours)**
Introduction to Optimization, Linear Programming – Formulation, Graphical method, simplex method and special cases.	
Sensitivity and post optimality analysis	**(08 hours)**
Sensitivity Analysis and post optimality analysis of linear programming problems – changes in resources and objective function, changes affect feasibility and optimality, duality, dual simplex algorithm, generalize simplex algorithm.	
Special types of linear programming problems	**(06 hours)**
Transportation problems, Transshipment problems, Travelling salesman problems, Integer programming.	
Introduction to MATLAB and solving linear and nonlinear problems using MATLAB	**(08 hours)**
Introduction to MALAB, creating and manipulating vectors and matrix, user defined function, special built-in function to create special vectors and matrices, symbolic math, built-in function to solve linear programming problems.	
Nonlinear programming problems	**(05 Hours)**
Graphical method, convex function and convex region, necessary and sufficient conditions, Lagrangian method, Karush-Kuhn-Tucker (KKT) conditions, solving nonlinear problems using MATLAB.	

Evolutionary Algorithms	(14 hours)
Introduction to evolutionary algorithm, introduction to multi-objective optimization, genetic algorithms, differential evolution algorithm, Particle swarm optimization, tabu search, simulated Annealing technique, solving real life engineering problems using MATLAB.	

(Total Lecture Hours: 45)

3. Books Recommended

1	F. S. Hillier, and G. J. Lieberman, Introduction to operations research: Concepts and *Cases*, Tata McGraw-Hill Education 8th edition, 2008.
2	H. A. Taha, Operations research: an introduction. Pearson Education India, 10th edition, 2016.
3	S. S. Rao, Engineering optimization: theory and practice. John Wiley & Sons, 3rdedition, 2018.
4	Xin- She Yang, Nature-Inspired Optimization Algorithms. Elsevier,1st edition 2014.
5	D. E. Goldberg, Genetic algorithms: in search, optimization and machine learning. Pearson Education India, 1st edition 2008

MEME123	**:**	**INDUSTRIAL ROBOTICS**	**L**	**T**	**P**	**Credits**
			3	**0**	**0**	**03**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO 1	Explain the basics of robotic systems.
CO 2	Apply the concept of robot arm kinematics.
CO 3	Analyze statics and dynamics of robots.
CO 4	Analyze manipulator trajectories.
CO 5	Analyze control of robot manipulators.
CO 6	Illustrate robot programming, sensing and vision.

2. Syllabus:

Introduction	**(04 Hours)**
Introduction to robots, robot manipulators, robot anatomy, coordinate systems, work envelope, types and classification, specifications, actuators and drives	
Mathematical Representation of Robots	**(06 hours)**
Rotations and translation of vectors, transformations and Euler angle representations, homogenous transformations, representation of position and orientation of a rigid body, homogeneous transformations, Denavit- Hartenberg (D-H) notations and parameters, representation of joints, link representation using D-H parameters	
Forward and Inverse Kinematics	**(05 Hours)**
Introduction, forward and inverse kinematics problems.	
Velocity and Statics Analysis	**(06 Hours)**
Linear and angular velocity of links, velocity propagation, Jacobians for robotic manipulators, statics and force transformation of robotic manipulators, singularity analysis	
Robot Dynamic Analysis	**(06 Hours)**

Introduction, forward and inverse dynamics, mass and inertia of links, Lagrangian formulation for equations of motion for robotic manipulators, Newton-Euler formulation method.	
Trajectory Planning and Control	**(11 Hours)**
Joint and Cartesian space trajectory planning and generation, classical control concepts using the example of control of a single link, Independent joint PID control, control of a multi-link manipulator, nonlinear model based control schemes.	
Force Control of Manipulators	**(02 Hours)**
Hybrid position/force control.	
Robot Programming, Sensing and Vision	**(05 hours)**
Robot Programming, Introduction to sensing and vision in robotics.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	A. Ghosal. Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2006
2	J. J. Craig. Introduction to Robotics: Mechanics and Control, 4th edition, Pearson, 2018
3	R. J. Schilling. Fundamentals of Robotics Analysis and Control, Pearson Education India, 2015
4	K. S. Fu, R. C. Gonzalez, C. S. G. Lee. Robotics: Control, Sensing, Vision, and Intelligence, McGraw Hill 1987
5	S. K. Saha. Introduction to Robotics, McGraw Hill Education India, 2014

MEME125	:	CONCURRENT ENGINEERING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Support the multi-disciplinary integrated product development teams and Plan and implement a new product development program.
CO2	Apply appropriate concurrent engineering tools and techniques to design and develop environment-friendly products by leveraging both manufacturing cost and lifecycle cost.
CO3	Determine the customer needs and ensure that the product design is robust and meets the professional standards with better quality.
CO4	Design and develop the products with high reliability, maintainability, and availability.
CO5	Apply the information technology tools for collaborative product design and development.
CO6	Demonstrate the applications of concurrent design of structures, products and components.

2. Syllabus:

Introduction	**(07 hours)**
Motivation, definition, and philosophy of Concurrent Engineering (CE); sequential and concurrent processes; Principles of CE; Organizing for CE; CE teams and team dynamics; Role of CAD/CAM/CAE/CIM and automation in CE; Managing product development projects; Decomposition of product development stages; Benefits of CE; Implementation issues of CE.	
Concurrent Engineering Tools and Techniques	**(24 hours)**
Design for manufacturing (DFM), Design for assembly (DFA); Factors influencing form design; Casting and machining considerations; Design for manufacturing and Assembly (DFMA) guidelines and examples; Lifecycle design of products with circular economy concept; Design for environment (DFE) with examples; Design for (-to-) cost; Design for X (DFX); Value engineering. Design for quality; Taguchi's methods for designing robust products; Design of Experiments (DOE) with examples; Design optimization; Quality function deployment (QFD) with examples. Design for reliability, maintainability and availability with examples; Failure modes and effects analysis (FMEA); Fault tree analysis	

(FTA); Rapid prototyping methods; Design simulation; Virtual and augmented reality environments for CE.	
Role of Information Technology in Concurrent Engineering	**(07 hours)**
Information technology (IT) components and functions; Artificial Intelligence for IT operations used for product design; Collaborative product development; Collaborative product commerce, Cloud IoT for CE.	
Selected Applications of Concurrent Engineering	**(07 hours)**
Design of aerospace and naval structures made of composite materials; Design of automotive components; Design of medical devices; Design of electronic products; Design of white goods parts.	

(Total Lecture Hours: 45)

3. <u>Books Recommended:</u>

1	B. Prasad. Concurrent Engineering Fundamentals I & II, Prentice Hall, New Jersey, 1996
2	I. Moustapha. Concurrent Engineering in Product Design and Development, New Age International, New Delhi, 2006
3	G. Boothroyd, P. Dewhurst, and W. Knight. Product Design for Manufacture and Assembly, 3rd Edition, Routledge, Boca Raton, 2010
4	J. R. Hartley. Concurrent Engineering: Shortening Lead Times, Raising Quality, and Lowering Costs, 4th Edition, Routledge, Boca Raton, 2017
5	K. T. Ulrich, S. D. Eppinger, and M. C. Yang. Product Design and Development, 7th Edition, McGraw Hill Education (India), Noida, 2020

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MEME127	:	COMPUTATIONAL FLUID DYNAMICS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain major theories, approaches and methodologies used in CFD
CO2	Demonstrate actual implementation skills of CFD methods (e.g. boundary conditions, different numerical schemes etc.)
CO3	Acquire working knowledge of computational complexity, accuracy, stability, and errors in solution procedures
CO4	Develop numerical models for fluid flow and heat transfer problems
CO5	Illustrate of advanced numerical techniques such as LBM, Meshless techniques.
CO6	Model real life engineering designs with CFD analysis

2. Syllabus:

Introduction to Computational Fluid Dynamics and Principle of Conservation	**(05 Hours)**
Introduction of Computational Fluid Dynamics: What, When, and Why?, CFD Applications, Numerical vs Analytical vs Experimental, Conservation of mass, Newton's second law of motion, Expanded forms of Navier-Stokes equations, Conservation of energy principle, Special forms of the Navier-Stokes equations, Classification of second order partial differential equations, Initial and boundary conditions, Governing equations in generalized coordinates	
Fundamentals of Discretization	**(08 Hours)**
Discretization principles: Pre-processing, Solution, Post processing, Finite Element Method, Finite difference method, Well posed boundary value problem, Possible types of boundary conditions, Conservativeness, Boundedness, Transportiveness, Higher order schemes to FDM, Finite volume method (FVM), Illustrative examples: 1-D steady state heat conduction without and with constant source term.	
Finite Volume Method	**(08 Hours)**

Some Conceptual Basics and Illustrations through 1-D Steady State Diffusion Problems: Physical consistency, Overall balance, FV Discretization of a 1-D steady state diffusion type problem, Composite material with position dependent thermal conductivity, Four basic rules for FV Discretization of 1-D steady state diffusion type problem, Source term linearization, Implementation of boundary conditions	
Discretization of Unsteady State Problems	**(04 Hours)**
1-D unsteady state diffusion problems: implicit, fully explicit and Crank-Nicholson scheme, FVM for 2-D unsteady state diffusion problems	
Discretization of Convection-Diffusion Equations	**(07 Hours)**
A Finite Volume Approach: Finite volume discretization of convection-diffusion problem: Central difference scheme, Upwind scheme, Exponential scheme and Hybrid scheme, Power law scheme, Generalized convection-diffusion formulation, Finite volume discretization of two-dimensional convection-diffusion problem, The concept of false diffusion, QUICK scheme	
Discretization of Navier Stokes Equations	**(06 Hours)**
Discretization of the Momentum Equation: Stream Function-Vorticity approach and Primitive variable approach, Staggered grid and Collocated grid, SIMPLE Algorithm, SIMPLER Algorithm	
Special Topics	**(07 Hours)**
Unstructured Grid Formulation, An overview of Finite Element Method, boundary element method, Lattice Boltzmann Method, Meshless Technique	

(Total Lecture Hours: 45)

3. <u>Books Recommended:</u>

1	S. V. Patankar, Numerical Heat Transfer and Fluid Flow, CRC Press, Indian Edition, 2017.
2	T. J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2nd edition, 2010
3	H. K. Versteeg & W. Malalasekera, An Introduction to Computational Fluid Dynamics, Pearson; 2nd edition, 2008
4	J. H. Ferziger and M.Peric, Computational Methods for Fluid Dynamics, Springer, 4th edition 2020

MEME129	:	DESIGN OF REFRIGERATION AND AIR CONDITIONING SYSTEMS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe the properties of refrigerants and evaluate performance of the actual vapour compression refrigeration systems.
CO2	Evaluate the performance of compound vapour compression refrigeration systems for various applications.
CO3	Describe vapour absorption system for large cooling load application and evaluate its performance.
CO4	Explain working principles of non-conventional refrigeration systems and evaluate the performance of steam jet refrigeration system.
CO5	Compute cooling/heating loads for designing air conditioning systems for residential and commercial building.
CO6	Design the air duct systems for large commercial buildings.

2. Syllabus:

VAPOUR COMPRESSION REFRIGERATION SYSTEM	(15 Hours)
Alternate Refrigerants – properties, applications, selection, mixed refrigerants, retrofit study, standard rating cycle for domestic refrigerator, refrigeration system components: compressors, condensers, expansion devices, evaporators, Multi stage compression with water intercooler, liquid sub cooler, flash chamber, flash intercoolers and multiple expansion valves, multi evaporator systems, cascade refrigeration system, Design aspects of refrigeration system components, solid CO_2 – dry ice cycle.	
VAPOUR ABSORPTION SYSTEMS	**(07 Hours)**
Temperature concentration and enthalpy concentration diagrams, enthalpy balance for various components of aqua ammonia systems, Vapour absorption system- Electrolux refrigerator.	
NON - CONVENTIONAL REFRIGERATION SYSTEMS	**(07 Hours)**
Steam jet refrigeration system, Performance analysis of steam jet refrigeration system, thermos electric refrigeration system, vortex tube Refrigeration, pulse tube refrigeration, adiabatic demagnetization, vapour adsorption refrigeration system	

AIR CONDITIONING	**(16 Hours)**
Review of air conditioning processes, summer and winter load calculations, cooling/heating load calculations, cooling coils, bypass factor, effective sensible heat factor, design consideration for cooling coils, high latent heat load, design of evaporative cooling system, de-humidifiers and air washers, Comfort air conditioning, thermodynamics of human body, comfort charts, effective temperature, central air conditioning system, Air handling unit, room air distributions, fluid flow and pressure losses, air filters, duct design Equal pressure drop method, velocity reduction method, static regain method, refrigeration and air conditioning controls	

(Total Lecture Hours: 45)

3. Books Recommended:

1	W. F. Stocker, and J. W. Jones, “Refrigeration and Air Conditioning”, McGraw Hill, N. Y. 2nd edition, 2014
2	R. J. Dossat, “Principles of Refrigeration”, John Wiley and Sons, 5th edition, 2001
3	C. P. Arora, Refrigeration and Air Conditioning, Tata McGraw Hill,3rd edition, 2017
4	S. C. Arora and S. Domkundwar, A course in Refrigeration and Air-conditioning, Dhanpat Rai & Sons, 7thedition, 2003.
5	ASHRAE Fundamentals, Applications, Systems and Equipment, Handbook, 2005

MEME131	:	OPERATIONS PLANNING AND CONTROL	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	:	Apply the different concepts of operations, productivity and forecasting.
CO2	:	Apply the tool related to the design of operations like capacity planning, constraint management, layout and location strategies.
CO3	:	Analyse the operations using the concept of supply chain, Inventory management and Aggregate planning.
CO4	:	Evaluate the operations using the concept of Material requirement planning and short term planning.
CO5	:	Formulate, analyze, design and synthesize open-ended operation planning and control problem using the various operation planning and control techniques.
CO6	:	Explain shop floor planning, order sequencing rules, and mathematical models for efficient production management.

2. Syllabus:

Operations planning & Control	**(03 Hours)**
Operations and Productivity, Operations Strategy in a Global Environment	
Forecasting	**(04 Hours)**
Elements and steps in forecasting, Types of forecasting, Demand forecasting using qualitative and quantitative methods, Errors in forecasting	
Capacity Planning and Constraint Management	**(04 Hours)**
Process Strategies, Definition and measurement of capacity, Adjusting capacity, Quantitative methods for capacity planning decision.	
Layout and Location Strategy	**04 Hours)**
Types of layout. Design of layout, Factors affecting location decision. Mathematical model for facility location and layout.	
Supply Chain	**05 Hours)**
The Supply Chain's Strategic Importance Sourcing Strategies, Supply Chain Risk Managing the Integrated Supply Chain Building the Supply Base, Supplier Evaluation, Supplier Development	
Inventory Control and Management	**(06 Hours)**
Introduction, EOQ Models with and without shortage, Multi item Deterministic Model, Dynamic and Fluctuating Models, Deterministic Model with price breaks and Probabilistic inventory models. Selective Inventory control.	
Aggregate Planning:	**(06 Hours)**
Purpose, inputs of aggregate plan, Aggregate planning Processes and strategies, Methods for	

aggregate planning, Aggregate planning in services.	
Material Requirement Planning and ERP	**(07 Hours)**
Just in Time, MRP input and output, MRP structure, MRP management, Lot sizing Technique and Extension of MRP, JIT and MRP in services, JIT to Die exchange, ERP: Introduction, Implementation, Advantages	
Short Term Scheduling	**(06 Hours)**
Introduction to Scheduling and Shop floor planning and control; order sequencing rules and their performance based on different evaluation criteria; changeover costs and job sequence, Mathematical models of job sequencing.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Jay Heizer, Barry Render and Chuck Munson, Amit Sachan, Operations Management, Pearson Education, 2017
2	Everett E. Adam, Ronald J. Ebert, Production and Operations Management, 5th edition, Prentice Hall of India, New Delhi, 2012
3	E. S. Buffa and R. K. Sarin, Modern Production / Operations Management, John Wiley & Sons, 1994
4	Samuel Eilon, Elements of Production Planning and Control. New York: Macmillan; London: Collier-Macmillan, 1962
5	Lee J. Knajei & L. P. Ritzman, Operations Management, Pearson Education, Delhi, 2002

MEME107	:	SOFTWARE PRACTICE	L	T	P	Credits
			0	0	4	02

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain data analysis, programming machine learning software's.
CO2	develop numerical solutions for linear and non-linear algebraic equations using computer programs
CO3	derive numerical solutions of initial value problems and boundary value problems.
CO4	solve ordinary differential equations (ODEs), and partial differential equations (PDEs) on a computer
CO5	develop code to solve one-dimensional optimization problems using the Golden Section Search method
CO6	show plotting of the graphs, writing equations and performing data analysis in Microsoft excel.

2. Syllabus:

Software:

1. Introduction to Origin software
2. Introduction to Minitab software
3. Introduction to Mathematica
4. Introduction to Mapple
5. Introduction to MATLAB
6. Introduction to functions of Microsoft Excel

Coding

1. Introduction to compiler, scripts, loops, logical statements
2. Finding of roots using Bisection method
3. Finding of roots using Newton-Rapson method
4. Solving ODE using Rung-Kutta method of 2nd order: Heun's method, Mid-point method, and Ralston's method
5. Solving ODE using Rung-Kutta method of 3rd order, and 4th order
6. Development of steady-state solver: (a) TDMA/ Line-by-line TDMA (b) Point-Jacobi (c) Gauss-Seidel Method (d) Gauss-Seidel over-relaxation Method
7. Development of transient solver: (a) Euler or Explicit scheme (b) Pure implicit scheme (c) Crank-Nicolson scheme (d) ADI
8. FDM code to solve PDE: elliptic equation
9. FDM code to solve PDE: parabolic equation
10. FDM code to solve PDE: hyperbolic equation

MEME109	**:**	**LABORATORY PRACTICE**	**L**	**T**	**P**	**Credits**
			0	**0**	**4**	**02**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO 1	Demonstrate operation of identified machine/instrument/equipment
CO 2	Perform given practical task independently on machine/instrument
CO 3	Analyse and evaluate the observations and deduce conclusions therein
CO 4	Represent results graphically and deduce conclusions therein
CO 5	Demonstrate practical skills to work on identified problem
CO 6	Develop skills for team effort and coordination through group practical performance

2. Practicals:

Students will perform any 08 practicals in various laboratories. The indicative list (but not limited to) of practicals is as under:

1. Evaluation of effect of process parameters on micro structure and strength of a part fabricated by given casting process
2. To perform various erosion tests on given part
3. To perform various wear tests on given part
4. To perform various NDT inspection for surface and sub-surface defects on given part
5. Demonstration of various composite manufacturing processes
6. Measurement of various features using microscope/ vision measuring instrument
7. Measurement of surface roughness of a given specimen
8. Integrating CAD /CAM/3D printing – CAE for given Product
9. Characterization and feature measurement on micro structure of given part with microscope
10. To conduct performance test on I C Engines
11. To study the different systems of automobile
12. Practicals pertaining to Welding Laboratory

MEME102	:	COMPUTER INTEGRATED MANUFACUTRING	L	T	P	Credits
			3	1	2	05

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Classify type of Automation and CIM.
CO2	Develop the CNC Program for the given geometry for Drilling, Milling and Turning machines.
CO3	Develop the part program using APT.
CO4	Analyze the production flow based on part classification, identification and coding.
CO5	Evaluate the different types of flexibilities in manufacturing.
CO6	Explain and evaluate types and steps of computer aided process planning

2. Syllabus:

Introduction to CIM	**(05 Hours)**
Introduction to automation, Types of automation, Automation principles and strategies, Definition of CIM, CIM wheel, Evolution of CIM, Benefits of CIM, CIM hardware and software, Nature and role of the elements of CIM system, Development of CIM	
Computer Aided Manufacturing	**(18 Hours)**
Components of NC/CNC system, Specification of CNC system, Classification of CNC machines, Constructional details of CNC machines, Axis designation, CNC control loops. Basic programming terms, Programming formats, Preparatory command, Miscellaneous functions, Machine zero, work zero and tool zero, Work offsets, Tool length offset and setup methods, Cutter radius offset, Machine zero return, Part programming for milling - linear and circular interpolation, subprogram, fixed/canned cycles, mirrors commands, machining large hole pattern, polar coordinates, round and rectangular pocket machining and cycles, subroutines, mirror, Part programming for lathe - lathe cycles, with and without tool nose radius feature, repetitive fixed cycle	
Part Programming with Automatically Programmed Tools (APT)	**(05 Hours)**
Computer aided part programming, APT: Geometry, motions and auxiliary commands, drill cycle commands, programming for geometry and drill cycle and hole pattern	
Group Technology	**(08 Hours)**
Definition, implementation considerations, benefits and applications, G.T. methods - visual search method, production flow analysis, Parts classification and coding, Design and manufacturing attributes, Concept of composite component, Rank order clustering, machine cell formation, Cell group tooling, Design rationalization, possibilities of integration with CAD/CAM	
Flexible Manufacturing System	**(06 Hours)**

Introduction, General Considerations for FMS, types of FMS, Flexibilities, their measurements, Computer control in FMS, Automated material handling systems, AGVs, Automatic storage and retrieval systems, Manufacturing cells, cellular v/s flexible manufacturing	
Computer Aided Process Planning	**(03 Hours)**
Introduction to CAPP, Route card, Manual and computer aided process planning, steps, and types	

(Total Lecture Hours: 45)

3. Books Recommended:

1	S.F. Krar, and A. Gill, CNC: Technology and Programming, McGraw-Hill, 1989
2	M. P. Groover, Automation, production systems, and computer-integrated manufacturing. Pearson Education India, 5th Edition, 2019
3	P. Radhakrishnan, S. Subramanyan, and V. Raju, CAD/CAM/CIM, New age International publishers, 3rd edition, 2011
4	P. N. Rao, CAD/CAM Principles and Applications, Tata McGraw Hill, 2nd Edition, 2006.
5	S. Kant Vajpayee, Principles of Computer Integrated Manufacturing, PHI, New Delhi, 1st edition, 1998

4. List of Practicals:

1. Demonstration of CNC Milling machine with user interface and calculating the Co-ordinates of given geometry in absolute and increment mode for cutter path.
2. Introduction of G codes and M codes and write the CNC part programming for a given geometry using Linear, Circular interpolation. (Using FANUC Controller)
3. Write the CNC part programming for a given geometry using Mirror and Subroutine. (Using FANUC Controller)
4. Write the CNC programming for a given geometry using Polar Co -ordinate for drilling cycles.
5. Write the CNC part programming for a given geometry using Tool Radius Compensation and Repeat loop for Peck Drilling Cycle. (Using FANUC Controller)
6. Introduction and programming of all canned cycle of Milling machine. (Using FANUC controller)
7. Demonstration and study of CNC Lathe machine with sample programming.
8. Write CNC programming for given geometry (Lathe) using stock removal cycles (Using FANUC controller)
9. Demonstration of FMS setup. (AS / RS, AGV, CNC Lathe, CNC Milling, Robot & CMM setup)
10. Demonstration of Advance manufacturing Machines like AJM (Abrasive Jet Machine), EDM (Electro Discharge Machine), µ Machine (Micro Machine), VMS (Vision Measuring System).

MEME104	:	MECHANICAL DESIGN ANALYSIS	L	T	P	Credits
			3	1	0	04

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Utilize the concept of theories of failure to machine components.
CO2	Evaluate the fatigue and creep behavior in machine parts and design against fracture.
CO3	Analyze impact, thermal properties and stresses in various machine elements like shafts and springs.
CO4	Design of various gear drives and gear boxes.
CO5	Design the various types of brakes, clutches and flywheel.
CO6	Design the fluid-film bearings, anti-friction bearings and I. C. engine components.

2. Syllabus:

Introduction	**(06 Hours)**
Design process, factor of safety and reliability in design, review of failure theories, loading conditions and stress concentration, surface stresses and their failures, lubricant films and their effects, Hertzian contact stresses and their effect on load capacities of machine members, effect of inelastic strains and residual stresses on load capacity of machine components, tolerances, limits and fits in design.	
Design for Fatigue Strength	**(10 Hours)**
Stress variation, design for fluctuating stresses, influence of low and high cycle fatigue, design for a limited number of cycles, cumulative damage, acoustical and thermal fatigue, fatigue strength of mechanical joints, shaft design. **Design for Creep and Fracture:** Creep and creep rupture, creep data for long-life design, stress relaxation in bolts, creep analysis of thin cylinders, thick-walled cylinders and rotating discs, designing against fracture, stress intensity factors, linear elastic fracture mechanics approach, theories of brittle fracture, fundamental aspects of crack growth and fractures, crack analysis for different laminas.	
Thermal Properties and Stresses	**(10 Hours)**
Effect of temperature on short term and long-term properties, elementary thermal stresses in machine elements, stress relaxation in bolts at elevated temperatures, detrimental residual stresses, bolt tightening. **Impact Energy:** Energy methods-general and particular cases, longitudinal stress waves in elastic media, impact on bars, torsional impact on shafts and longitudinal impacts on helical springs, striking of two bars.	
Design of Brakes and Clutches:	**(09 Hours)**
Work, torque, and motion in brake and clutch systems, short contacts on the cylindrical surfaces of drums, long shoes on cylindrical surfaces, design of band and block brake, shoe brake, external and internal expanding brakes, drum and disc brakes, types of mechanical clutches, design of single and multiple disc clutches, cone and centrifugal clutch, selection of friction materials for brakes and clutches, temperature rise, railway brakes.	
Design of Bearings and Power Transmission Elements:	**(10 Hours)**

Selection of hydrodynamic and hydrostatic bearings, selection of anti-friction bearings, classification of gears, design of spur, helical, bevel and worm gear drives, speed reducers and gear boxes. **Design of Internal Combustion Engine Components and Flywheel:** Cylinder and cylinder liners, piston, connecting rod, crank-shaft and valve-gear mechanism, construction and torque analysis of solid and rimmed flywheel, stresses in flywheel, design of engine flywheel.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	A. H. Burr and J. B. Cheatham, Mechanical Analysis and Design, Prentice-Hall, 1995
2	R. G. Budynas and J. K. Nisbett, Shigley's Mechanical Engineering Design, McGraw Hill Publications, 2016
3	J. A. Collins, H. Busby and G. Stabb, Mechanical Design of Machine Elements and Machines: A Failure Prevention Perspective, Wiley India, 2010
4	R. C. Juvinall and K. M. Marshek, Fundamentals of Machine Component Design, Wiley India, 2020
5	R. L. Norton, Machine Design: An Integrated Approach, Pearson Education, 2020.

MEME112	:	RENEWABLE ENERGY SYSTEMS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	design solar systems for a given energy utility by applying principles of solar energy conversion
CO2	design bio-energy based systems for a given utility by applying principles of bio-mass to bio-energy conversion
CO3	assess theoretical and practical performance of wind turbines including optimal tip speed ratio requirement
CO4	characterize different types of waste and compare various conversion technologies suitable for industrial applications in line with government approved RDF and MSW policies.
CO5	compare hydrogen production methods and use of hydrogen resource with other energy resources in present context
CO6	compare different types of fuel cells and understand its working

2. Syllabus:

Solar radiation	**(12 Hours)**
Extra-terrestrial and terrestrial, Solar radiation measuring instruments, Estimation of Solar Radiation, Various earth-sun angles. Solar Energy Conversion Systems: Solar Thermal Systems: Basics, Flat plate collectors-liquid and air type. Theory of flat plate collectors, selective coating, advanced collectors, Concentrators: optical design of concentrators, solar water heater, solar dryers, solar stills, Solar ponds, solar cooling and refrigeration, Solar thermal power generation. Solar Photovoltaic Systems: Principle of photovoltaic conversion of solar energy, Solar cells, Home lighting systems, Solar lanterns, Solar PV pumps, Govt. policies. Introduction to Solar Photovoltaic Thermal Systems (PV/T): Air based, Water based, Refrigerant based Systems. Solar energy storage options: Electrical and Thermal Energy storage options for Solar Energy.	
Biomass & Bioenergy	**(12 Hours)**
Biogas System: Anaerobic digestion, biogas production, Types of digesters, installation, operation and maintenance of biogas plants, Biogas plant manure utilisation and manure values, factors affecting biogas production, Biogas utilisation and storage, Compressed Biogas (CBG) production from agro waste; biogas for motive power generation, design calculations for biogas plants, Govt. policies. Liquid Biofuels: Biodiesel – The mechanism of transesterification, fuel characteristics of biodiesel, technical aspects of biodiesel/Ethanol and other liquid fuels	

utilization in engine. Biomass gasification: Different types of gasifier, power generation and applications	
Wind Energy Conversion Systems	**(08 Hours)**
History of wind energy, Current status and future prospects, Wind energy in India. Power available in the wind, Components of Wind Energy Conversion Systems, Horizontal and Vertical axis wind turbine, Wind turbine power and torque characteristics, Tip speed ratio, Optimal tip speed ratio, Wind speed prediction and forecasting, Betz limit, Govt. Policies.	
Waste to Energy Conversion	**(08 Hours)**
Introducing Municipal Solid Waste Management; Waste Generation and characterization, Waste Processing Techniques; Source Reduction, Biological Conversion Products: Compost and Biogas, Incineration pyrolysis and Energy Recovery, waste plastic, RDF/Sewage utilization, Govt. Policies on MSW and RDF, Introduction to Microbial Fuel Cell.	
Hydrogen Energy and Fuel Cells	**(05 Hours)**
Benefits of Hydrogen Energy, Hydrogen Production Technologies, Hydrogen Energy Storage, Use of Hydrogen Energy, Electrolysis, Bio-hydrogen Production, Biogas reformation to Syngas, Basic principle of working of fuel cell.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	J. A. Duffie and W.A. Beckman, Solar Engineering and Thermal Processes, John Wiley and Sons., 2013
2	H. S. Mukunda, Understanding Clean Energy and fuels from biomass. Wiley India Pvt. Ltd, 2011
3	K. M. Mital, Biogas Systems, Principle and Applications. New Age International Ltd, 1996
4	G. D. Rai, Non-Conventional Energy Sources, Khanna Publication, 1988
5	Prabir Basu, Biomass Gasification And Pyrolysis: Practical Design And Theory, Academic Press, 1st Edition, 2010

MEME114	:	DESIGN OF PRESSURE VESSELS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Illustrate the different types of loads and their effects in pressure vessel.
CO2	Evaluate the different types of stresses in pressure vessel.
CO3	Design the various supports of the pressure vessel.
CO4	Design the shells, heads and nozzles.
CO5	Apply the ASME & IS codes to Design pressure vessel.
CO6	Evaluate the various stresses under thermal and fatigue loadings.

2. Syllabus:

Introduction	**(11 Hours)**
Overview of various parts of pressure vessels, classification of pressure vessels, applications, factors influencing the design of vessels - material selection, loads & types of failures.	
Stresses in pressure vessels	**(11 Hours)**
stresses in circular ring, cylinder & sphere, membrane stresses in vessels under internal pressure, thick cylinders, multi layered cylinders, auto-frottage of thick cylinders and their significance, discontinuity and buckling stresses	
Design of pressure vessels as per ASME and IS code	**(12 Hours)**
Introduction and importance of codes, Externally and internally pressurized vessels, tall vertical vessels, Supports for vertical & horizontal vessels, nozzles and flanges. shells and heads	
Pressure vessels with different conditions:	**(11 Hours)**
Evaluation of pressure vessels for different conditions: hydro-test condition, thermal stresses, FEM analysis, Fatigue of pressure vessels.	

(Total Lecture Hours: 45)

3. Books Recommended

1	J. F. Harvey. Theory and Design of Pressure Vessels, Springer US, 2007.
2	S. Chattopadhyay. Pressure Vessels: Design and Practice, CRC Press, 2004.
3	ASME Code Section 8thDiv 1, Div2, ASME, 2021.
4	A. S. Tooth. Pressure Vessel Design: Concepts and Principles, 1st Edition, CRC Press, 2012.
5	D. R. Moss, M. M. Basic. Pressure Vessel Design Manual, 4th Edition, Elsevier Science, 2012.

MEME116	**:**	**THEORY AND DESIGN OF CRYOGENIC SYSTEMS**	**L**	**T**	**P**	**Credits**
			3	**0**	**0**	**03**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Select suitable cryogen and material for development of cryogenic system for different applications.
CO2	Design and analyze gas liquefaction system and cryogenic refrigeration systems including cryocoolers.
CO3	Select proper cryogenic insulating material and designing of cryogenic insulation.
CO4	Analyze gas purification and separation system using cryogenics.
CO5	Select and design storage, handling, and transfer systems for cryogens.
CO6	Design vacuum system for cryogenic application.

2. Syllabus:

INTRODUCTION AND APPLICATIONS	**(02 Hours)**
CRYOGENICS FLUIDS	**(02 Hours)**
Properties of air, Oxygen, Nitrogen, Hydrogen, Helium and its isotopes	
PROPERTIES AND SELECTION OF MATERIALS	**(03 Hours)**
Study of material properties & their selection for cryogenic application.	
GAS LIQUEFACTION and REFRIGERATION SYSTEMS	**(10 Hours)**
Basics of Refrigeration, Ideal system, Linde Hampson system, Precooled Linde Hampson system, Linde dual pressure system, Claude system, Heylandt system, Kapitza system, Collins cycle	
CRYOGENIC INSULATION	**(07 Hours)**
Vacuum insulation, Multilayer insulation (MLI), Methods of measuring effective thermal conductivity of MLI, Liquid & vapour shield, Evacuated porous insulation, Gas filled powders and fibrous materials, Solid foams, Vacuum technology	
CRYOCOOLERS	**(07 Hours)**
Ideal Stirling cycle, Design parameters (Schmidt's Analysis), GM cryocoolers, Pulse Tube cryocooler, Phasor Analysis	
CRYOGENIC INSTRUMENTATION	**(05 Hours)**
Peculiarities of cryogenic strain measurement, Pressure, Flow, Density, Temperature and liquid level measurement for cryogenic application	

STORAGE & HANDLING SYSTEMS	(04 Hours)
Dewar vessel design, Piping, Support systems, Vessel safety devices and storage systems, Industrial storage systems	
TRANSFER SYSTEMS	**(03 Hours)**
Transfer from storage, Uninsulated transfer lines, Insulated lines, Transfer system components.	
GAS SEPARATION	**(02 Hours)**
Principles of gas separation, Ideal system	

(Total Lecture Hours: 45)

3. Books Recommended:

1	C. Hastlden, Cryogenic Fundamentals, Academic Press, 2001.
2	R. Barron, Cryogenic Systems, Plenum Press, 2001
3	G. Walker, Cryocoolers, Springer, 2014
4	Y. Mikulin, Theory and Design of Cryogenic systems, MIR Publication, 2002.
5	R. F. Barron, Cryogenics Systems, Oxford Press., USA, 2002

MEME118	:	QUALITY ENGINEERING AND MANAGEMENT	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

CO1	Explain different concepts of quality, system reliability & maintenance and its application to the design and manufacturing activities
CO2	Apply statistical concepts and techniques for designing of products and process controls
CO3	Describe and apply reliability analysis concepts to selected applications
CO4	Describe and Apply the two level factor factorial design, general factorial design and surface response method for experimental design.
CO5	Formulate, analyze, design and synthesize open-ended quality engineering problems using the various statistical process control tools and quality management tool
CO6	Select and apply newer concepts and initiatives for quality improvement

2. Syllabus:

Introduction	**(02 Hours)**
Introduction to quality control and the quality system, some philosophies and their impact on quality, Cost of quality, Quality audit.	
Statistical Quality Control	**(14 Hours)**
Statistical Concepts and Data analysis: Fundamentals of statistical concepts and techniques in quality control and improvement, Data analysis and sampling; Control Charts: Statistical Process Control using control charts, Control charts for attributes and variables. Process capability analysis: Concepts and procedures of Process capability. Acceptance Sampling: Acceptance sampling for attributes and variables.	
Reliability Analysis	**(05 Hours)**
Reliability: Failure rate analysis, mean failure rate, mean time to failure, mean time between failure, Graphical representation of Fd, Z and R. Generalization in graphical form, integral form, Hazard models, systems reliability, availability, maintenance, overall equipment effectiveness, Total Productive Maintenance (TPM), Failure Mode and Effect Analysis (FMEA).	

Experimental Design	**(08 Hours)**
Experimental Design: Fundamentals of experimental Design, Single, Multi factor and 2k factor experiments, Two level fractional factorial design, Response surface method. Quality loss function. Taguchi method: Taguchi method, Design of experiments using orthogonal array, Data analysis from Taguchi and Multi level factor design.	
New Quality Concepts and Initiatives	**(12 Hours)**
New Quality Concepts and initiatives: Total Quality Management (TQM) and its techniques, New Seven Management Tools, and Industrial Case studies on Costs of Quality, Five S, kaizen, Quality Circles, Quality Function Deployment (QFD), Poka Yoke, Total Productive Maintenance (TPM), Lean Manufacturing, Six Sigma, Lean Six Sigma, etc. Quality Management through Software.	
Quality Standards	**(03 Hours)**
Quality Standards and Business Excellence Models: Quality System Standards, ISO 9000, ISO 14000, various Quality Awards and case studies.	
World Class Manufacturing	**(01 Hour)**
Manufacturing Excellence World Class Manufacturing (WCM) – Model and elements of WCM.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Amitra Amitava, Fundamentals of Quality Control and Improvement, 2nd Ed., Prentice Hall of India, 2011
2	K. Krishnaiah and P. Shahabudeen, Applied Design of Experiments and Taguchi Methods, Prentice Hall of India, 2012
3	Dale H. Besterfield, Carol Besterfield-Michna, Mary Besterfield-Sacre, Glen H. Besterfield, Hemant Urdhwareshe, Rashmi Urdhwareshe, Total Quality Management, , Pearson Education, 2012
4	George W. Cobb, Introduction to Design and Analysis of Experiments, John Wiley & Sons, 2015
5	D.C. Montogomery, Design and Analysis of Experiments, John Wiley & Sons, 8th Edition, 2013

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MEME120	:	ADVANCED WELDING TECHNOLOGY	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Relate the significance of welding in various industrial sectors.
CO2	Explain the characteristics of welding arc and relate it importance during welding process
CO3	Develop the concepts of various advanced welding technologies.
CO4	Analyse the heat flow and metal transfer mechanism in welding.
CO5	Determine the solidification mechanism of weld pool.
CO6	Compile the quality of weldments by monitoring and controlling the process through advanced techniques.

2. Syllabus:

Introduction	**(04 Hours)**
Welding as compared with other fabrication processes, classification, weldability, weld configuration, ASME standards for weldments, scope and applications of welding in various industrial sectors.	
Physics of Welding Arc	**(08 Hours)**
Structure and characteristics of welding arc, methods of arc initiation and maintenance, arc stability, voltage distribution along the arc, cathode and anode drops, arc column, thermionic and non-thermionic cathode, theories of cathode and anode mechanisms, temperature distribution in the arc, arc efficiency, heat generation at cathode and anode, effect of shielding gas on arc, isotherms of arcs, arc blow, arc welding power sources, heat sources for solid state welding.	
Advanced Welding Processes	**(12 Hours)**
Overview of arc welding processes, flux cored arc welding, plasma transferred arc welding, electro-gas and electro-slag welding, resistance welding, magnetic pulse welding. Theory and mechanism of solid state welding, technique and scope of - friction welding, fiction stir welding, diffusion welding, cold pressure welding, ultrasonic welding, electron beam welding, laser beam welding. Cladding through welding, automation in welding.	

Heat Flow and Metal Transfer in Welding	**(08 Hours)**
Calculation of peak temperature, width of heat affected zone, cooling rate and solidification rates, weld thermal cycles. Forces, mechanism and types of metal transfer in various arc welding processes, factors controlling melting rate in various welding processes. Residual stresses and their measurement, weld distortion and its prevention.	
Solidification of weld pool	**(05 Hours)**
Principle of solidification of weld metal, modes of solidification, effect of welding parameters on weld structure, grain refinement principle of weld metal, method of weld metal refinement: inoculation, arc pulsation, external excitation.	
Inspection and Quality Control of Weldments	**(08 Hours)**
Overview of post weld characterization, weld related discontinuities, Welding Defects, overview of standard destructive and nondestructive testing applicable for weldments, inspection of weldments, importance of welding procedure and performance qualification, monitoring and control of welding processes, welding simulation.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	P. T. Houdlecroft, "Welding Process Technology", Cambridge University Press, 3rd edition, 2004
2	W. A. Bowditch, K. E. Bowditch, "Welding Technology Fundamentals", Goodheart-Willcox Co. Pub., 1991
3	L. Jeffus, "Welding: Principles and Applications", Cengage Learning Pub., 7th edition, 2011
4	J. F. Lancaster, "Metallurgy of Welding", Springer publications, 6th edition, 2009
5	R. S. Parmar, "Welding Engineering and Technology", Khanna Publishers, 5th edition, 2013

MEME122	:	DESIGN OF EXPERIMENTS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Formulate objective(s) and identify key factors in designing experiments for a given problem.
CO2	Develop appropriate experimental design to conduct experiments for a given problem.
CO3	Identify randomization, replication, blocking and degree of freedom based on given parameters and their levels
CO4	Analyze experimental data to derive valid conclusions.
CO5	Optimize process conditions by developing empirical models using experimental data.
CO6	Design robust products and processes using parameter design approach.

2. Syllabus:

Fundamentals of Experimentation	**(06 Hours)**
Role of experimentation in rapid scientific progress, Historical perspective of experimental approaches, Steps in experimentation, Principles of experimentation	
Simple Comparative Experiments	**(09 Hours)**
Basic concepts of probability and statistics, Comparison of two means and two variances, Comparison of multiple (more than two) means & ANOVA	
Experimental Designs	**(08 Hours)**
Factorial designs, fractional factorial designs, orthogonal arrays, standard orthogonal arrays & interaction tables, modifying the orthogonal arrays, selection of suitable orthogonal array design, analysis of experimental data	
Response Surface Methodology	**(10 Hours)**
Concept, linear model, steepest ascent, second order model, regression	
Taguchi's Parameter Design	**(12 Hours)**
Concept of robustness, noise factors, objective function & S/N ratios, inner-array and outer-array design, data analysis.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	P. J. Ross, Taguchi Techniques for Quality Engineering, McGraw-Hill Book Company, New York, 1st edition, 2008
2	D. C. Montgomery, Design and Analysis of Experiments, John Wiley & Sons, New York, 7th Edition, 2008
3	Jiju Antony, Design of Experiments for Engineers and Scientists, Elsevier, 2nd edition, 2018
4	Colin Hardwick, Practical Design of Experiments, Createspace Independent Publisher, 1st edition, 2013
5	Angela Dean, Max Morris, John Stufken, Derek Bingham. Handbook of Design and Analysis of Experiments. Chapman and Hall/CRC; 1st edition, 2020

MEME124	:	DESIGN AND ANALYSIS OF COMPOSITE STRUCTURES	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Classify types of composite materials.
CO2	Analyse the macro mechanical behaviour of lamina.
CO3	Analyse the micro mechanical behaviour of lamina.
CO4	Analyze the macro mechanical behaviour of laminate.
CO5	Evaluate the bending, buckling and vibration of laminated plate.
CO6	Determine the design requirement of composite materials.

2. Syllabus:

Introduction	**(06 Hours)**
Classification and characteristics of composite materials, Mechanical behaviour of composite materials, Terminology of laminated composite materials, Manufacture of laminated composite materials, Applications of composite materials	
Macro-Mechanical Behaviour of a Lamina	**(07 Hours)**
Stress-strain relationship for anisotropic materials, Stiffness, compliances and engineering constants for orthotropic materials, Relationship on engineering constants, Stress-strain relationship for plane stress in an orthotropic material, Strength of an orthotropic lamina	
Micro-Mechanical Behaviour of a Lamina	**(06 Hours)**
Mechanics of materials approach to stiffness, Elasticity approach to stiffness, Mechanics of materials approaches to strength.	
Macro-Mechanics Behaviour of a Laminate	**(07 Hours)**
Classical laminate theory, Special cases of laminate stiffness, Theoretical versus measured laminate stiffness, Strength of laminates, Interlaminar stresses	
Bending, Buckling and Vibration of Laminated Plates	**(10 Hours)**
Governing equations for bending, buckling and vibration of laminated plate, Deflection of simply supported laminated plates under distributed transverse load, Buckling of laminated plate, Vibration of laminated plate.	
Introduction to Design of Composite Structures	**(09 Hours)**
Introduction, Introduction to structural design, Material Selection, Configuration Selection, Laminate joints, Design requirements and design failure criterion	

(Total Lecture Hours: 45)

3. **Books Recommended:**

1	K. K. Autar. Mechanics of composite materials, 2nd Edition, CRC Press, 2006.
2	R. M. Jones. Mechanics of composite materials, 2nd Edition, Taylor and Fransis, 2018.
3	M. M. Kaminski. Computational mechanics of composite materials, Springer, 2005.
4	B. D. Agarwal. Analysis and Performance of Fiber Composites, 3rd Edition, John Wiley & Sons, 2006.
5	R. F. Gibson, Principles of Composite Material Mechanics, 4th Edition, CRC Press, 2016

MEME126	:	COMBUSTION FOR PROPULSION SYSTEMS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Analyse the combustion system using principles of thermodynamics.
CO2	Model combustion kinetics and chemical explosion mechanisms
CO3	Explain basic concepts about various types of flames; modelling and application to energy systems.
CO4	Analyse combustion characteristics and how these can be measured.
CO5	Illustrate different type of pollutants generated by combustion, their effects on health and on the environment and various methods to control it.
CO6	Describe different combustion mechanisms and how these can be efficiently used in engineering applications.

2. Syllabus:

Introduction	**(04 Hours)**
Introduction to combustion, Applications of combustion, Types of fuel and oxidizers, Characterization of fuel, Various combustion mode, Scope of combustion, Fundamental laws of transport phenomena, Conservations Equations.	
Thermodynamics of Combustion	**(08 Hours)**
Mixture composition, energy and entropy properties of gaseous mixtures, Thermodynamic properties of reacting mixtures, Laws of thermodynamics, Stoichiometry, Thermochemistry, adiabatic temperature, chemical equilibrium. Conditions of chemical equilibrium, equilibrium constant, challenges in chemical equilibrium.	
Combustion Kinetics	**(08 Hours)**
Basic Reaction Kinetics, Elementary reactions, Chain reactions, Multistep reactions, simplification of reaction mechanism, Global kinetics reaction rate formula, approximations for construction of global reaction rate, global rates of hydrocarbon fuels.	
Chemical Mechanisms	**(03 Hours)**
Explosive and oxidative characteristics of fuels, Criteria for explosion, Explosion limits and oxidation of hydrogen, Carbon monoxide and hydrocarbons.	
Premixed Flames	**(06 Hours)**
Laminar premixed flame, laminar flame structure, Stability limits of laminar flames, Laminar flame speed, Flame speed measurements, Flame stabilizations, Ignition and quenching, Turbulent flames, turbulent flame speed, external aided ignition (spherical propagation, plane propagation), auto ignition, flammability limits.	
Diffusion Flames	**(06 Hours)**
Laminar Diffusion flames, turbulent diffusion flames, Schvab-Zel'dovich formulation, Burke-Schumann problem, Gaseous Jet diffusion flame, Droplet Combustion, Liquid fuel combustion, Atomization, Spray and Solid fuel combustion.	
Combustion and Environment	**(04 Hours)**

Atmosphere, Chemical Emission from combustion, Quantification of emission, mechanisms of pollutant formation during combustion, pollutants reduction in conventional combustors, pollutants reduction by control of flame temperature, dry low-oxides of nitrogen combustors, lean premix per vaporize combustion, rich-burn quick-quench lean burn combustor, catalytic combustion, correlations and modelling of oxides of nitrogen and carbon monoxide emission.	
Combustion Process in Propulsion Systems	**(06 Hours)**
Principal ideas of combustion in gas turbine, solid propellant rockets: Erosive burning, and liquid propellant rockets.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	K. K. Kuo, Principles of Combustion, John Wiley and Sons, 2005
2	S. R. Turns, An introduction to combustion, New York: McGraw-Hill, 2017
3	C. K. Law, Combustion physics, Cambridge University Press, 2010.
4	D. P. Mishra, Fundamentals of Combustion, Prentice Hall of India, 2010
5	H. S. Mukunda, Understanding combustion, Universities Press, 2009.

MEME128	:	DESIGN OF HEAT EXCHANGERS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Identify different types of heat exchangers and understand the basic design methodologies
CO2	Design and analyse the double pipe shell and tube heat exchanger
CO3	Design and perform the thermal performance of tube finned and plate finned heat exchanger
CO4	Estimate thermal performance of Gasketed and Spiral plate heat exchanger
CO5	Estimate the pressure drop in tubular and extended surface heat exchanger
CO6	Estimate furnace outlet temperature using furnace model

2. Syllabus:

Introduction	**(06 hours)**
Application of heat exchanger, classification of heat exchanger, design and simulation of heat exchanger, Review of heat transfer principles & convection correlation, Basic design methodologies, Net Transferable Units method and Logarithmic Mean Temperature, Examples	
Design of Tubular Heat Exchanger	**(10 hours)**
Heat transfer coefficient, double pipe heat exchanger design, Shell & tube type heat exchangers, nomenclature, J-factors, conventional design methods, bell, Delaware method	
Design of Extended Surface Heat Exchanger	**(15 hours)**
Enhancement of heat transfer compact heat exchanger, Compact heat exchangers, J-factors, Design method Extended surface heat exchanger, Rating problem of tube finned heat exchanger, Rating problem of plate finned heat exchanger, Pressure drop calculations and tutorials, Sizing problem	
Design of Plate Heat exchangers	**(05 hours)**
Introduction, Types of the plate heat exchanger, thermal design of Gasketed plate heat exchanger, thermal design of spiral plate heat exchanger	
Heat Exchanger Pressure Drop Analysis	**(05 hours)**
Importance of pressure drop, Major contributions to the heat exchanger pressure drop, Tubular heat exchanger pressure drop, Extended surface heat exchanger pressure drop, Plate heat exchanger pressure drop	
Furnace design	**(04 hours)**

Design development of Stirred Reactor Furnace model, Estimate the furnace outlet temperature

(Total Lecture Hours: 45)

3. Books Recommended:

1	R. K. Shah, and D. P. Sekulic, “Fundamentals of Heat Exchanger Design”, John Wiley & Sons, Inc, 2003
2	V. A. Kays, and A. L. London, “Compact Heat Exchangers”, McGraw Hill, 2002
3	Holger Martin, “Heat Exchangers” Hemisphere Publ. Corp. Washington, 2001
4	T. Kuppan, “Heat Exchanger Design Handbook”, Macel Dekker, Inc., N.Y., 2000
5	Seikan Ishigai, “Steam Power Engineering, Thermal and Hydraulic Design Principles”, Cambridge Univ. Press, 2001

MEME130	**:**	**NON DESTRUCTIVE TESTING**	**L**	**T**	**P**	**Credits**
			3	**0**	**0**	**03**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the basic concept of NDT and its industrial applications
CO2	Select appropriate NDT technique to identify given defect.
CO3	Identify internal flaw in the part and suggest measures to eliminate it
CO4	Analyse available data using modern tools and softwares
CO5	Propose environmental friendly solutions to the industrial problem through NDT
CO6	Identify and overcome limitations of NDT technique through alternative techniques

2. Syllabus:

1.	**Introduction to NDT, Liquid Penetrant Test**	**(06 Hours)**
	Physical Principles, Procedure for penetrant testing, penetrant testing materials, Penetrant testing methods, sensitivity, Applications and limitations, typical examples.	
2.	**Ultrasonic Testing**	**(08 Hours)**
	Basic properties of sound beam, Ultrasonic transducers, Inspection methods, Techniques for normal beam inspection , Techniques for angle beam inspection, Flaw characterization techniques, Applications of ultrasonic testing , Advantages and limitations.	
3.	**Thermography**	**(06 Hours)**
	Basic principles, Detectors and equipment, techniques, applications.	
4.	**Radiography**	**(07 Hours)**
	Basic principle, Electromagnetic radiation sources, radiographic imaging, Inspection techniques, applications, limitations, typical examples.	
5.	**Eddy Current Test**	**(06 Hours)**
	Principles, instrumentation for ECT, techniques, sensitivity, advanced eddy Current test methods, applications, limitations.	
6.	**Acoustic Emission**	**(06 Hours)**

	Principle of AET, Technique, instrumentation, sensitivity, applications, Acoustic emission technique for leak detection.	
7.	**Magnetic Particle Inspection**	**(06 Hours)**
	Principle of MPT, Procedure used for testing a component, sensitivity, limitations.	

(Total Lecture Hours: 45)

3. <u>Books Recommended:</u>

1	Peter J. Shull, Nondestructive Evaluation: Theory, Techniques and Applications, Marcel Dekkar, 1st edition, 2002
2	Ravi Prakash, Non Destructive Testing Techniques, New Age International Publishers, 1st edition, 2010
3	M. Sadashiva, Non Destructive Testing, Notion Press, 1st edition, 2021
4	ASM Metals Hand Book, Non Destructive Testing and Quality Control, Vol. 17, ASM, 1989
5	Mix Paul, Introduction to NDT: A training guide, John Wiley and Sons, 2nd edition, 2005

MEME172	:	INDUSTRIAL SAFETY	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe causes of accidents and their consequences, and applicable safety laws
CO2	Identify hazards and manage risk
CO3	Measure safety performance
CO4	Formulate safety and health policy
CO5	Conduct the accident investigation
CO6	Establish fire control system

2. Syllabus:

INTRODUCTION	**(04 Hours)**
Accident fatalities across the globe, nature of industry, review of accident statistics in India, types of injuries, causes of accidents, consequences of accidents, responsibilities of stakeholders	
Accident causation theories:	**(07 Hours)**
Accident proneness theories, Goals- Freedom-Alertness theory, adjustment stress theory, theory of mental stress, dominoes theories, chain of events theory, distraction theory, the human error-causation model, behaviour theory	
Hazard identification and risk assessment:	**(07 Hours)**
Types of hazards**,** identification of hazards and risk, risk analysis, risk evaluation, risk ranking, risk acceptance, risk control, , and risk transfer, A *priori* risk estimates, ergonomics and cognitive assessment methods, task demand assessment methods	
Measurement of safety performance:	**(05 Hours)**
Reactive indicators, proactive indicators, permanent total disabilities, permanent partial disabilities, temporary total disabilities, computations of accident indices, problems	
Safety and health management policy:	**(04 Hours)**
Safety policy, budget, organization, inspection, audit, education and training, safety health and environment plan, safety manual, committee, incentive programmes	
Accident investigation and analysis methods:	**(06 Hours)**
Accident investigation, reporting, record keeping, gathering information of accident, root cause analysis, fault tree analysis, failure modes and effect analysis, hazard and operability study review, etc., case study	
Safety laws :	**(06 Hours)**
History of safety acts in India, the factory Act, 1948, the building and other construction workers Act, 1996, occupational safety health and working condition code,2020, the	

contract labour Act, 1970, the hazardous wastes rules, 1989, motor vehicle Act,1988, the industrial relations code bill, 2020, the code on social security bill,2020, etc.	
Fire Safety Management:	**(06 Hours)**
Fire properties of solid, liquid and gases, Sources of ignition, fire triangle, principles of fire extinguishing, active and passive fire protection systems, various classes of fires, types of fire controlling apparatus, industrial fire protection system, explosive protection system	

(Total Lecture Hours: 45)

3. Books Recommended:

1	L. M. Deshmukh, Industrial safety management. New Delhi: Tata McGraw Hill, 2010
2	B. S. Dhillon, Applied Safety for Engineers: Systems and Products. CRC Press, 2022
3	D. L. Goetsch, Occupational Safety and Health for Technologists, Engineers and Managers, Pearson Education, Inc., Upper Saddle River, New Jersey 2005
4	H. W. Heinrich, Industrial Accident Prevention. A Scientific Approach. Industrial Accident Prevention. A Scientific Approach., (Second Edition), 1941
5	K. N. Jha, D. A. Patel, A. Singh, Construction safety management, Pearson India Education Services Pvt. Ltd., Noida (India), 2022

MEME174	:	INTELLIGENT MANUFACTURING SYSTEMS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the need and capability of AI based manufacturing system
CO2	Identify the characteristics and components of knowledge based expert systems
CO3	Apply probability and fuzzy logic for machine thinking
CO4	Apply the ANN modeling to identified manufacturing problem
CO5	Develop the knowledge based GT for selected automation system
CO6	Design an intelligent system for various manufacturing systems

2. Syllabus:

Concepts of Artificial Intelligence	**(09 Hours)**
Origin of Artificial Intelligence, Human and machine Intelligence, Branches of artificial intelligence, Programming in AI environment, Emergence of expert systems, Applications in Engineering and Manufacturing, Intelligent Manufacturing Systems – System components, System Architecture and Data Flow and System Operation	
Knowledge Based Systems/Expert Systems	**(14 Hours)**
Expert systems: Expert system process, characteristics and components of expert systems, Knowledge Acquisition: Knowledge acquisition phases, Methods of extracting knowledge from experts, Knowledge acquisition meetings, Group knowledge acquisition, Knowledge Representation: Characteristics of knowledge, Knowledge representation models, Concepts of knowledge sets and Reasoning models. Expert system justification and future directions for expert systems	
Machine Learning	**(10 Hours)**
Machine Learning – Concept, Artificial Neural Networks, Biological and Artificial Neuron, Types of Neural Networks, Applications in manufacturing, Use of probability and fuzzy logic for machine thinking.	
Knowledge Based Group Technology	**(08 Hours)**
Group Technology: Models and Algorithms – Visual method, Coding method, Cluster analysis method, Knowledge based group technology – Group technology in automated manufacturing system, Structure of knowledge based system for group technology (KBSGT) – Database, Knowledge base, Clustering algorithm	
Industrial Applications of AI	**(04 Hours)**

Intelligent system for design, equipment selection, scheduling, material selection, maintenance, facility planning and process control	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Michael Negnevitsky, Artificial Intelligence: A guide to Intelligent systems, Pearson, 3rd edition, 2020
2	A. B. Badiru, Expert Systems Applications in Engineering and Manufacturing, Prentice-Hall, New Jersey, 1992
3	Andrew Kussiak, Intelligent Manufacturing Systems, Prentice Hall, 1990
4	Kishan Mehrotra, Elements of Artificial Neural Network, Penram International Publishing Pvt Ltd; 2nd edition, 2009
5	Rajendra Akerkar, Knowledge based Systems, Jones & Bartlett, 1st edition, 2009

MEME176	:	ENERGY CONSERVATION MANAGEMENT AND AUDIT	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Apply various energy conservation techniques to estimate energy saving potential in various thermal and electrical utilities
CO2	Compare various appliances/utilities based on their stars and labelling, benchmarking values, PAT Scheme in industries
CO3	Calculate the usage of energy for a given industrial thermal/electrical utility and suggest suitable way to minimize energy bill
CO4	Analyse the saving potential of Cogeneration option for process industry
CO5	Determine Energy conservation potential in various industrial utilities like fans, blowers, compressors, pumps etc.
CO6	Compute various performance parameters of HVAC systems and suggest suitable ways for improving energy efficiency

2. Syllabus:

Global and National Energy Scenario	**(10 Hours)**
Energy consumption in various sectors, Energy resources like Coal, Oil and Natural Gas – their demand and supply management, Indian energy scenario, Indian Coal & LPG scenario, Primary and Secondary Sources of Energy, Commercial and Non-Commercial Sources, India’s installed energy capacity, per capita energy consumption. General aspects of Energy conservation and management, Roles of energy auditors, Roles of energy manager, Energy policy of industry, Energy Conservation Act and its amendments, PAT Scheme. Star and Labelling	
Energy Efficiency in Boiler, Steam And Furnace System Utilities	**(08 Hours)**
Energy conservation opportunities in boiler systems, retrofitting of FBC in conventional boilers, Steam line distribution standard practices including sizing and layouts, selection, operation and maintenance of steam traps, energy saving opportunities in steam systems.	
Energy Efficiency in Furnaces and Refractories	**(06 Hours)**
Sankey diagram, Fuel economy measures in furnaces Insulation and Refractories: Types of insulations, Economic thickness of insulation, Typical refractories for industrial applications. Benchmarking in Glass and Steel Industries.	
Cogeneration	**(06 Hours)**
Principle of cogeneration, technical options for cogeneration, Factors influencing cogeneration choice, Important technical parameters for cogeneration, case study on savings with and without cogeneration	
Energy Conservation in Fans, Blowers, Compressors and Pump Systems	**(10 Hours)**

Energy saving opportunities, performance evaluation and efficient system operation. Air Systems: Efficient operation of Fans, Blowers and compressed air system, Energy conservation opportunities in Fans, Blowers and Compressors. Compressor Leakage tests. Pumps and Pumping Systems: Pump curves, factors affecting pump performance, Energy loss in throttling, Effects of impeller diameter change, Flow control strategy, Variable speed drives, Energy conservation opportunities.	
Energy Conservation in HVAC and Cooling Towers	**(05 Hours)**

(Total Lecture Hours: 45)

3. Books Recommended:

1	General Aspects of Energy Conservation, Management and Audit: Guide Book for Energy Managers and Energy Auditors; Bureau of Energy Efficiency, Ministry of Power
2	Energy Efficiency in Electrical Utilities: Guide Book for Energy Managers and Energy Auditors; Bureau of Energy Efficiency, Ministry of Power
3	Energy Efficiency in Thermal Utilities: Guide Book for Energy Managers and Energy Auditors; Bureau of Energy Efficiency, Ministry of Power
4	S. A. Roosa, Energy Management Handbook, Fairmont Press, 2018
5	Wayne C Turner, Energy Management Handbook. Prentice Hall 3rd Edition, 2000

MEME178	**:**	**ENERGY AND BUILDINGS**	**L**	**T**	**P**	**Credits**
			3	**0**	**0**	**03**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO 1	express the importance of climate, building and energy.
CO 2	illustrate daylight and lightings for energy efficiency perspective.
CO 3	analyze ventilation and air quality in buildings.
CO 4	estimate building load and develop methods to reduce it.
CO 5	evaluate energy efficiency in buildings.
CO 6	distinguish green building rating systems, life cycle and environmental assessments and contribution of renewable energy.

2. Syllabus:

Introduction	**(05 hours)**
Understanding building energy use, concepts of energy efficiency potential in buildings, effect of climates on building energy usage.	
Daylight and lighting in buildings	**(05 hours)**
Introduction, Types of technology, design considerations, operation and maintenance, relevant codes and standards.	
Ventilation and air quality in buildings	**(09 hours)**
Types of ventilation systems, Passive and active methods of heating and cooling with their layouts, performance of room air distribution systems, cooling comfort in hot climates.	
Estimation of building loads	**(12 hours)**
Steady state method, Network method, Numerical method, Correlations, Computer packages for carrying out thermal design of buildings and predicting performance.	
Energy Efficiency in buildings	**(06 hours)**
Energy efficient building technologies, energy efficiency policies, Building codes and standards, energy efficient building operation, evaluation of energy efficiency.	

Advances in Building:	(08 hours)
Life cycle perspective and environmental assessment of buildings. Renewable Energy in Buildings; Sustainable Building Rating Systems	

(Total Lecture Hours: 45)

3. Books Recommended:

1	David Thorpe, Energy Management in Buildings The Earthscan Expert Guide, , 1st Ed, Routledge, 2014
2	Mili Majumdar, Energy-efficient Buildings in India, , The Energy and Resources Institute (TERI), 2001
3	Sofia-Natalia Boemi, OlatzIrulegi, Mattheos Santamouris, Energy Performance of Buildings, Energy Efficiency and Built Environment in Temperate Climates., Springer Nature, 2016
4	Andreas Athienitis, William O'Brien, Modeling, Design, and Optimization of Net-Zero Energy Buildings, First published, Wiley, 2015
5	Bruce D. Hunn and Charles B. Fundamentals of Building Energy Dynamics: 4 (Solar Heat Technologies): Volume 4, The MIT Press, 1996

MEME180	**:**	**INSTRUMENTATION AND EXPERIMENTAL METHODS**	**L**	**T**	**P**	**Credits**
			3	**0**	**0**	**03**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Analyze functional stage and transducers
CO2	Explain model measuring and instrument responses.
CO3	Analyze experimental errors, uncertainties, and appropriate test methods.
C04	Explain advancements in sensor and transducer technology.
CO5	Assess data acquisition and signal processing systems
CO6	Illustrate flow and temperature measurement devices

2. Syllabus:

Significance of Measurement and Instrumentations	**(05 Hours)**
Introduction, generalized configuration and functional stages of measuring systems, the transducer and its environment, an overview, sensing process and physical laws, Types of measurement problems. Transducer classification and their modelling, characteristics of instruments, design and selection of components of a measuring system.	
Dynamic Response of Instruments	**(05 Hours)**
Mathematical model of a measuring system, response of general form of instruments to various test inputs; time domain and frequency domain analysis Elementary transfer functions, Bode plots of general transfer functions.	
Errors in Measurement and Uncertainty in measurements	**(08 Hours)**
Errors in instruments, Causes and types of experimental errors, Analysis of experimental data and determination of overall uncertainties in experimental investigation, Uncertainties in measurement of measurable parameters like pressure, temperature, flow etc. under various conditions, Estimation for design and selection for alternative test methods.	
Transducers	**(08 Hours)**
Developments in sensors, detectors and transducer technology, displacement transducers; force, torque and motion sensors, piezoelectric transducers, capacity type transducers, Strain gauge transducers, Accelerometers, pressure transducers based on elastic effect of volume and connecting tubing. Transducers for Position, speed, vibration, sound, humidity, and moisture measurement, Hall effect Transducer.	
Data Acquisition and Signal Processing	**(06 Hours)**
Systems for data acquisition and processing modules and computerized data system digitization rate, time and frequency domain representation of signals, and Nyquist criterion a brief description of elements of mechatronics modular approach to mechatronics and	

engineering design.	
Advanced Flow Measurements	**(07 Hours)**
Basic flow meters, magnetic, ultrasonic flow meters, Flow visualization, shadowgraph, Schlieren and interferometric techniques, Pitot static tubes; hot wire anemometers, flow measuring problems, Laser Doppler velocity meter, flow measurements using coriolis effect.	
Temperature Measurements	**(06 Hours)**
Modes of heat transfer, laws of conduction, convection and radiation, Temperature scales, classification of Temperature Sensors, Overview of Temperature Sensor Material, Expansion thermometers, filled system thermometers Thermoelectric sensors, electric resistance sensors; thermistors, Electrical temperature instruments, thermocouples, RTD, and thermistors, Pyrometers, IR temperature detectors, radiations pyrometers, Temperature measuring problems in flowing fluids, dynamic compensation	

(Total Lecture Hours: 45)

3. Books Recommended:

1	J. P. Holman, “Experimental methods for engineers”, McGraw Hill, NY, USA, 2017
2	E. O. Doebelin and D. N. Manik “Measurement systems: application and design”, McGraw Hill, NY, USA, 2019
3	S. P. Venktesh “Mechanical measurements”, John Wiley & Sons Ltd, USA, 2021
4	R. Goldstein “Fluid mechanics measurements,” Taylor & Francis, USA, 2017
5	M. R. Sheldom, “Introduction to probability and statistics for engineers and scientist”, Elsevier, 5th edition, Amsterdam, Netherland, 2014

MEME106	**:**	**MINI PROJECT**	**L**	**T**	**P**	**Credits**
			0	**0**	**4**	**02**

At the end of the course the students will be able to:

CO 1	Relate with latest areas of Mechanical Engineering
CO 2	Survey field problems pertaining to mechanical engineering
CO 3	Improve & augment skills with hands on training
CO 4	Utilize various software skills to design, develop the product before fabrication
CO 5	Analyze the computation results with experimental results
CO 6	Create technical report & defend with presentation on the chosen area of mini project

Note: The students are expected to identify the prospective faculty for the proposed mini project work. The PG In-charge will float the form and prepare the list of students and prospective faculty for mini project at the beginning of the given semester. The concern faculty will take periodic review of the progress of work. The candidate is supposed to submit the report based on the mini project work assigned by concerned faculty. The faculty will evaluate the same at his/her level and will submit the marks. The report will be kept for record purpose.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence
Integrated B.Tech. + M.Tech. in Artificial Intelligence

Sr. No.	Subject	Code	Scheme L-T-P	Credits (Min.)	Notional hours of Learning (Approx.)
	First Semester (1st year of IPG)				
1	Fundamentals of Computer and Programming	IA101	3-0-2	4	85
2	Fundamentals of Engineering Mathematics	MA105	3-1-0	4	70
3	Linear Algebra and Statistics	MA116	3-1-0	4	70
4	English and Professional Communication	HS110	3-1-0	4	70
5	Electrical Network Analysis	EE103	3-0-2	4	85
			Total	**20**	**380**
6	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	IAV01 / IAP01	0-0-10	5	200 (20 x 10)
	Second Semester (1st year of IPG)				
1	Data Structures	IA102	3-1-2	5	100
2	Web Programming and Python	IA104	3-0-2	4	85
3	Energy and Environmental Engineering	EG110	3-0-2	4	85
4	Discrete Mathematics	MA106	3-1-0	4	70
5	Digital Electronics and Logic Design	EC106	3-0-2	4	85
6	Indian Value System and Social Consciousness	HS120	2-0-0	2	35
			Total	**23**	**460**
7	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	IAV02 / IAP02	0-0-10	5	200 (20 x 10)
	Third Semester (2nd year of IPG)				
1	Computer Organization	IA201	3-1-0	4	70
2	Database Management Systems	IA203	3-0-2	4	85
3	Design and Analysis of Algorithms	IA205	3-1-0	4	70
4	Signals and Systems	EC205	3-1-0	4	70
5	Object Oriented Programming	IA209	3-0-2	4	85
6	Automata and Formal Languages	IA211	3-1-0	4	70
			Total	**24**	**450**
	Fourth Semester (2nd year of IPG)				
1	Artificial Intelligence	IA202	3-1-0	4	85
2	Operating Systems	IA204	3-0-2	4	85
3	Machine Learning	IA206	3-0-2	4	85
4	Computer Networks	IA208	3-0-2	4	85
5	Information Security and Cryptography	IA210	3-1-0	4	70
6	Data Science	IA212	3-1-0	4	70
			Total	**24**	**480**
7	Minor / Honor (M/H#1)	IA2AA	3-X-X	3/4	55/70/85
8	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	IAV04 / IAP04	0-0-10	5	200 (20 x 10)
	Fifth Semester (3rd year of IPG)				
1	Deep Learning	IA301	3-0-2	4	85

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

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2	Cloud Computing	IA303	3-0-2	4	85
3	Soft Computing	IA305	3-0-2	4	85
4	Elective	IA3AA	3-X-X	3/4	55/70/85
5	Elective (Specialization#1)	IA3BB	3-X-X	3/4	55/70/85
6	Linear and Nonlinear Optimization	IA307	3-1-0	4	70
			Total	**22-24**	**435-495**
7	Minor / Honor (M/H#2)	IA3CC	3-X-X	4	70/85
	Sixth Semester (3rd year of IPG)				
1	High Performance Computing	IA302	3-0-2	4	85
2	Cyber Physical System	IA304	3-0-2	4	85
3	Big Data Analytics and Visualization	IA306	3-0-2	4	85
4	Elective	IA3DD	3-X-X	3/4	55/70/85
5	Elective (Specialization#2)	IA3EE	3-X-X	3/4	55/70/85
6	Image Processing and Computer Vision	IA308	3-0-2	4	85
			Total	**22-24**	**450-510**
7	Minor / Honor (M/H#3)	IA3FF	3-X-X	3/4	70/85
8	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	IAV06 / IAP06	0-0-10	5	200 (20 x 10)
	Seventh Semester (4th year of IPG)				
1	Swarm Intelligence	IA401	3-0-2	4	85
2	Research Methodology	IA403	1-1-0	2	35
3	Robotics and Applications	IA405	3-0-2	4	85
4	Elective	IA4BB	3-X-X	3/4	55/70/85
5	Elective (Specialization#3)	IA4CC	3-X-X	3/4	55/70/85
6	Elective (Specialization#4)	IA4DD	3-X-X	3/4	55/70/85
7	Minor Project-I	IA407	0-0-10	5	150
			Total	**24-27**	**520-610**
8	Minor / Honor (M/H#4)	IA4EE	3-X-X	3/4	55/70/85
	Eighth Semester (4th year of IPG)				
1	Intelligent Multiagent and Expert Systems	IA402	3-0-2	4	85
2	Professonal Ethics, Business and Entrepreneurship	HUXXX	3-1-0	4	70
3	Human Computer Interaction	IA404	3-1-0	4	70
4	Elective	IA406	3-X-X	3/4	55/70/85
5	Elective	IA408	3-X-X	3/4	55/70/85
6	Elective	IA410	3-X-X	3/4	55/70/85
7	Minor Project-II	IA412	0-0-10	5	150
			Total	**26-29**	**540-630**
	Nineth Semester (5th year of IPG)				
1	MOOC-I	IA501	2-0-0	2	35
2	MOOC-II	IA503	2-0-0	2	35
3	M.Tech. Thesis Part-I	IA505	0-0-36	18	540
			Total	**22**	**610**
	Tenth Semester (5th year of IPG)				
1	M.Tech. Thesis Part-II	IA502	0-0-40	20	600
			Total	**20**	**600**

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

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Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence

Credit Table

Sr.	Domain	Credit	Percentage
1	Basic Sciences	12	5.28 /5.06 %
2	Humanities	6	2.64 / 2.53 %
3	Management	4	1.76/ 1.68 %
4	Engineering other branches	18	7.92 / 7.59 %
5	Core subjects	105	46.25 / 44.30 %
6	Electives	34/44	14.97 / 18.56 %
7	Project	48	21.14/20.25
Total		**227/237**	**100 %**

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

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Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence

Integrated B.Tech.+M.Tech. I (AI) Semester – I FUNDAMENTAL OF COMPUTER AND PROGRAMMING IA101	Scheme	L	T	P	Credit
		3	0	2	04

1.	**Course Outcomes (COs):** **At the end of the course, students will be able to**
CO1	Understand the basic concepts of computers and programming.
CO2	Apply the knowledge of C Programming to solve computational problems.
CO3	Debug, test, and analyse C Programs to find and correct errors and improve the solutions.
CO4	Learn various programming techniques such as iteration and recursion, and apply them to solve computational problems.
CO5	Learn and apply the advanced programming concepts such as modularization, memory management, and file handling to improve the efficiency of computational problems.

2.	**Syllabus**	
	INTRODUCTION TO COMPUTER ARCHITECTURE AND OPERATING SYSTEM	**(05 Hours)**
	Computer Architecture, Input unit, Output unit, Storage Unit, Central Processing Unit, Introduction of Operating System, Function OS, Unix Commands.	
	OVERVIEW OF C PROGRAMMING LANGUAGE	**(04 Hours)**
	Concepts Of High-Level, Assembly And Low-Level Languages, History of C, Importance of C, Representing Algorithms through Pseudocode and Flowchart, Basic Structure of a C Program, How to Compile a C Program, How to Run a C Program, Sample Programs.	
	CONSTANTS, VARIABLES, AND DATA TYPES	**(02 Hours)**
	Character Set in C, Keywords, Identifiers, Constants, Strings, Operators, Special Symbols, Variables, Data Types: Primary Data Types and User Defined Data Types, Declaration of Variables, Assigning Values to Variables, Initialization of Variables, Defining Symbolic Constants, Declaring Variables as Constants.	
	OPERATORS, EXPRESSIONS AND LIBRARY FUNCTIONS	**(04 Hours)**
	Operators: Arithmetic, Relational, Logical, Assignment, Increment and Decrement, Conditional, Bitwise, Comma Operator, sizeof Operator, Operators used in Pointers and Structures, Arithmetic Expressions, How C programming Evaluates Arithmetic Expressions, Precedence of Arithmetic Operators and Associativity Rule, Type Conversion: Implicit and Explicit. Reading Character from Keyboard, Printing Character on Screen, Reading String from Keyboard, Printing String on Screen, Formatting input and	

	Output, Math Functions.	
	DECISION MAKING, BRANCHING, AND LOOPING	**(06 Hours)**
	Decision Making in C Programming, If Statement, Nested If Statement, Else If Ladder, Switch Statement, Conditional Operator Statement, Goto Statement, Decision Making with Logical Operators, Sample Programs. Introduction to Loops, While Loop, Do While Loop, For Loop, Break Statement, Goto Statement, Continue Statement, Sample Programs.	
	ARRAYS AND CHARACTER ARRAYS	**(05 Hours)**
	Introduction to Arrays, One Dimensional Array, Declaration and Initialization of One Dimensional Array, Two Dimensional Array, Declaration and Initialization of Two Dimensional Array, Multi-Dimensional Array, Sample Programs, Declaration and Initialization of Strings, Arithmetic Operations on Characters, String Functions: Strlen(), Strcat(), Strcpy(), Strstr(), Strcmp(), etc.	
	FUNCTIONS	**(05 Hours)**
	Function Declaration, Function Definition, Function Calls, Functions with No Arguments and No Return Values, Functions with Arguments and No Return Values, Functions with No Arguments and Return Values, Functions with Arguments and Return Values, Recursive Functions, Passing Arrays to Functions, Call by Value, Call by Reference, Scope and Lifetime of Functions: Local, Global, Static, and Register Declaration.	
	STRUCTURES AND UNIONS	**(04 Hours)**
	Structure Template, Structure Variable Declaration and Initialization, Structure Variable Assignment, Accessing Structure Variables, Arrays as Structure, Arrays with Structures, Passing Structure Members to Functions, Unions, Difference Between Structures and Unions, Bit Fields.	
	POINTERS AND MEMORY MANAGEMENT	**(05 Hours)**
	Declaration and Initialization of Pointers, Accessing Memory through Pointers, Pointer to Pointer, Pointer Arithmetic, Dynamic Memory Allocation, Memory Management Functions: Malloc, Calloc, and Free, Using Pointers to Access Dynamically Allocated Memory Locations, Pointers with Arrays, Function and Structure, Use of Pointers to Return Multiple Values From Functions.	
	FILE MANAGEMENT AND PREPROCESSOR	**(05 Hours)**
	Opening and Closing a File, Modes in File Opening: Read, Write and Append, Input and Output, Operations on Files, File Handling Functions such as fseek(), ftell(), rewind(). Pre-processor directives, Macro Substitution, Importing a File, Compiler Control Directives, Command Line arguments	
	Practicals will be based on the coverage of the above topics separately.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

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3.	**Practical**
1	C Programming – How to write a program, compile a program, and execute a program
2	Read the input from a keyboard and write the output to computer screen
3	Variable declaration, initialization, and assignment, Constant declaration, Experiments with different data types
4	Experiments with different C Operators, Analysing the impact of precedence and associativity rules while evaluating expressions in C
5	Experiments with standard library functions related to math library, time library, standard input and output library etc.
6	Experiments with If, Else If, Switch, Goto statements
7	Experiments with While, Do...While, For Loops, and analysing the impact of Break, Goto and Continue statements on C Loops
8	Experiments with Arrays and Character Arrays
9	Experiments with Different Functions having Arguments/No Arguments and Return Values/No Return Values, Scope and Lifetime of Functions, and Understanding Local, Global, Static, and Register Declaration
10	Experiments with Structures and Unions, Analysing the difference between the structure and union with respect to memory
11	Experiments with Pointers with respect to Accessing Memory from the Stack and Heap Section of the RAM (i.e., Experiments with Static and Dynamic Memory Management)
12	Opening, Closing the Files using a C program, and accessing the files to get the input from the file and store the output to the file.
13	Experiments with pre-processor directives.

4.	**Books Recommended**
1.	Introduction to Computer Science", Fourth Impression, Pearson Education, ITL EducationSolutions Limited, 2009.
2.	Nell Dale and John Lewis, "Computer Science Illuminated", Jones and Bartlett Publishers.
3.	E. Balagurusamy, "Programming in ANSI C", Mc-Graw Hill.
4.	Brian W. Kernighan / Dennis Ritchie,"The C Programming Language", Pearson.
5.	Yashavant Kanetkar, "Let us C", BPB Publications.
6.	Harbison and Steele, "C: A Reference Manual"

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Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence

Integrated B.Tech.+M.Tech. I (AI) Semester – I FUNDAMENTALS OF ENGINEERING MATHEMATICS MA105	Scheme	L	T	P	Credit
		3	1	0	04

1.	**Course Outcomes (COs):** **At the end of the course, the students will be able to**
CO1	Accept the challenge to solve the problem with Mathematics.
CO2	Apply the knowledge of curve tracing to solve problem of engineering.
CO3	Identify, formulate and analyze complex engineering and affiliated field problems, specifically the differential equation concept in different engineering field.
CO4	Apply the knowledge of mathematics for model and analyze computational processes using analytic and combinatorial methods
CO5	Design solutions engineering industrial problems with effective mathematical skill.

2.	**Syllabus**	
	DIFFERENTIAL CALCULUS	**(09 Hours)**
	Differentiation of Hyperbolic and Inverse Hyperbolic functions. Successive Differentiation, standard forms, Leibnitz's theorem and applications, Power series, Expansion of functions, Taylor's and Maclaurin's series. Curvature, Radius of curvature for Cartesian curve with application.	
	PARTIAL DIFFERENTIAL CALCULUS	**(09 Hours)**
	Partial differentiation, Euler's theorem for homogeneous function, Modified Euler's theorem, Taylor's and Maclaurin's series for two variables. Tangent plane and Normal line, Error and Approximation, Jacobians with properties, Extreme values of function of two variables, Lagrange's methods of undetermined multipliers.	
	CURVE TRACING	**(06 Hours)**
	Cartesian, polar and parametric form of standard curves.	
	ORDINARY DIFFERENTIAL EQUATION	**(09 Hours)**
	Reorientation of differential equation first order first degree, exact differential equation and Integrating factors, first order higher degree odes, solvable for p, y and x, Solution of homogenous equations higher order, complementary functions, Particular Integrals, Linear differential equation with variable coefficient, Cauchy's Euler and Legendre's equation with variable coefficient, Method of variation of parameters.	
	APPLICATION OF DIFFERENTIAL EQUATION (MATHEMATICAL MODELLING)	**(06 Hours)**
	Modelling of Realworld problems particularly Engineering System, Electrical network models (LCR), spread of epidemic (SI, SIS, SIR), Newton's Law of cooling, Compartment modelling, Bending of beam models.	

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	SERIES SOLUTION AND SPECIAL FUNCTIONS	**(06 Hours)**
	Regular point, Singular point, series solution of ODE of 2nd order with variable coefficient with special emphasis to differential equation of Legendre's and Bessel's for different cases of roots of indicial equations.	
	Tutorials will be based on the coverage of the above topics separately.	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3.	**Tutorials**
1	Tutorial will be related to Differential Calculus.
2	Tutorial will be on Radius of curvature for Cartesian curve with application.
3	Tutorial will be on different examples of Partial Differential Calculus.
4	Tutorial will be on Extreme values of function of two variables.
5	Tutorial will be on Curve Fitting.
6	Tutorial will cover Ordinary differential equations.
7	Tutorial will be on examples of Higher order Ordinary differential equations.
8	Tutorial will be on examples of Application of Ordinary differential equations.
9	Tutorial will be on Series solution with ordinary point
10	Tutorial will be on with Series solution with regular singular point

4.	**Books Recommended**
1	James Stewart, "Calculus", Thomson Asia, Singapore, 2003.
2	Kreyszing E., "Advanced Engineering Mathematics", John Wiley & Sons, Singapore, Int. Student Ed. 2015.
3	Wiley C. R., "Advanced Engineering Mathematics", McGraw Hill Inc., New York Ed. 1993.
4	F. B. Hilderband, "Methods of Applied mathematics", PHI, New Delhi, 1968
5	Ramana D. V., "Higher Engg. Mathematics", The McGraw-Hill Inc., New Delhi, 2007.

ADDITIONAL REFERENCE BOOKS	
1	Srimanta Pal, Subodh C. Bhunia, "Engineering Mathematics", Oxford University Press, New Delhi, 2015.

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2	Bali and Iyengar, "Engineering Mathematics", Laxmi Publications, New Delhi, 2004.
3	Mary L. Boas, "Mathematical Methods in the Physical Sciences", John Wiley & Sons, Ed.2005

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Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence

Integrated B.Tech.+M.Tech. I (AI) Semester – I LINEAR ALGEBRA AND STATISTICS MA116	Scheme	L	T	P	Credit
		3	1	0	04

1.	**Course Outcomes (COs):** **At the end of the course, students will be able to**
CO1	accept the challenge to solve the problem with statistics
CO2	apply the knowledge of Linear Algebra to solve problem of engineering.
CO3	identify, formulate and analyze complex engineering and affiliated field problems, specifically the Partial differential equation concept in different engineering field
CO4	apply the knowledge of vector calculus and analyze computational processes
CO5	design solutions to work on engineering industrial problems with effective mathematical skill.

2.	**Syllabus**	
	PROBABILITY THEORY AND RANDM PROCESS	**(09 Hours)**
	Fundamentals of Probability Theory: - views of probability, Random variables and Joint distributions, Marginal distribution, Conditional probability, Conditional independence, Expectation and variance, Probability distributions Central limit theorem, Functions of random variable, Sum of independent random variable, Correlation and regression, Random process, Stationary random process, Autocorrelation and cross correlation, Ergodic process, Markov process, Birth and death process, Poisson process, Markov chain, Chapman Kolmogorov theory, Spectral analysis of random processes, power spectral density.	
	ESTIMATION AND STATISTICS	**(08 Hours)**
	Sampling theory, Population and sample, Statistical interference, Sampling distribution, Sample mean, Bias estimation, Unbiased estimator, Confidence interval, Point estimation and interval estimates, Statistical decision, Hypothesis testing, Statistical hypotheses, Null hypotheses, Significance test, Type I and types II errors, Level of significance, One tail and two tailed test, Chi square test, Maximum likelihood estimate, Least square estimate, MAP estimate, Minimum mean square estimate.	
	INTRODUCTION TO PARTIAL DIFFERENTIAL EQUATION	**(09 Hours)**
	Introduction to Partial differential equation, Formation of partial differential Equation, Partial differential Equation of first order, Linear partial differential equation of first order (Pp + Qq =R) and method of obtaining its general solution, Non-linear partial differential equation of first order f(p, q)=0, f(z, p, q)=0, f(x, p)= g(y, q), z= px + qy + f(p,q).	
	BASIC CONCEPTS OF VECTOR CALCULUS	**(08 Hours)**

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

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	Scalar and vector point function, differential operator, gradient, directional derivative, divergence, curl and Laplacian operator with their properties.	
	LINEAR ALGEBRA	**(11 Hours)**
	Linear systems, Elementary row and column transformation, rank of matrix, consistency of linear system of equations, Linear Independence and Dependence of vectors, Gauss Elimination method, Gauss-Jorden Method, Gauss-Jacobi Iteration Method; Vector spaces, Subspace, Field, Ring, Norm and distance, Linear Mapping, Orthogonality, Eigenvectors and Eigenvalues, Least square, Least square data fitting, Constrained least square applications.	
	Tutorials will be based on the coverage of the above topics separately.	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3.	Tutorials
1	Tutorial will be related to Probability theory.
2	Tutorial will be on Randomness.
3	Tutorial will be on Estimation theory.
4	Tutorial will be on Partial differential Equation.
5	Tutorial will be on special type of Partial differential Equation.
6	Tutorial will covered on basics of Vector calculus.
7	Tutorial will be on examples of divergence, curl and Laplacian operator.
8	Tutorial will be on examples Liner algebra.
9	Tutorial will be on Eigenvectors and Eigen values.
10	Tutorial will be on Least square, Least square data fitting, Constrained least square applications

3.	Books Recommended
1	Kreyszing E., "Advanced Engineering Mathematics", John Wiley & Sons, Singapore, Int. Student Ed. 2015.
2	Wiley C. R., "Advanced Engineering Mathematics", McGraw Hill Inc., New York Ed. 1993.
3	Gilbert Strang, "Introduction to Linear Algebra", Wellesley Cambridge Press, 4th Ed., 2009.
4	David C. Lay, "Linear Algebra and its applications", 3rd Ed., Pearson, 2006.
5	A. Papoulis and S. U. Pillai, "Probability, Random Variables and Stochastic Processes", 4th Ed., Mc-

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	Graw Hill, 2002.

ADDITIONAL REFERENCE BOOKS	
1	Ramana D. V., "Higher Engg. Mathematics", McGraw-Hill Inc., New Delhi, 2007.
2	Srimanta Pal, Subodh C. Bhunia, "Engineering Mathematics", Oxford University Press, New Delhi, 2015.
3	Mary L. Boas, "Mathematical Methods in the Physical Sciences", John Wiley & Sons, Ed.2005.

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Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence

Integrated B.Tech.+M.Tech. I (AI) Semester – I ENGLISH AND PROFESSIONAL COMMUNICATION HS110	Scheme	L	T	P	Credit
		3	1	0	04

1.	Course Outcomes (COs): At the end of the course, the students will be able to
CO1	show enhanced reception towards the use of English language.
CO2	choose and employ appropriate words for professional communication.
CO3	develop sentences and text in English coherently and formally.
CO4	demonstrate overall improvement in oral communication.
CO5	analyze and infer from written and oral messages.

2.	Syllabus	
	COMMUNICATION	**(05 Hours)**
	Introduction to Communication, Different forms of Communication, Barriers to Communication and some remedies, Non-Verbal Communication – Types, Non-Verbal Communication in Intercultural Context.	
	VOCABULARY AND USAGE OF WORDS	**(05 Hours)**
	Common Errors, Synonyms, Antonyms, Homophones, and Homonyms; One Word Substitution; Misappropriations; Indianisms; Redundant Words.	
	LANGUAGE THROUGH LITERATURE	**(09 Hours)**
	Selected short stories, essays, and poems to discuss nuances of English language.	
	LISTENING AND READING SKILLS	**(06 Hours)**
	Types of listening, Modes of Listening-Active and Passive, Listening and note taking practice, Practice and activities Reading Comprehension (unseen passage- literary /scientific/technical) Skimming and scanning, fact vs opinion, Comprehension practice	
	SPEAKING SKILLS	**(10 Hours)**
	Effective Speaking, JAM, Presentation Skills- types, preparation and practice. Interviews-types, preparation and mock interview; Group Discussion- types, preparation and practice	
	WRITING SKILLS	**(10 Hours)**

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

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	Prerequisites of effective writing, Memo-types, Letter Writing- types, Email etiquette and Netiquette, Résumé-types, Report Writing and its types, Editing.	
	Tutorials will be based on the coverage of the above topics separately	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3.	Tutorials
1	Letter and Resume
2	Group Discussion
3	Presentation Skills (Individual)
4	Role Play on Nonverbal communication
5	Group Presentation
6	Debate
7	Body language and intercultural communication
8	Listening Activities
9	Editing
10	Report Writing
11	Mock interviews
12	JAM

4.	Books Recommended
1	Kumar, Sanjay and Pushp, Lata. *Communication Skills*, 2nd Edition, OUP, New Delhi, 2015.
2	Raman, Meenakshi & Sharma Sangeeta. *Technical Communication Principles and Practice*, 3rd Edition, OUP, New Delhi, 2015.
3	Raymond V. Lesikar and Marie E Flatley. *Basic Business Communication skills for Empowering the Internet generation.* Tata McGraw Hill publishing company limited. New Delhi 2005.
4	Courtland L. Bovee, John V. Thill, and Mukesh Chaturvedi. "Business Communication Today." Ninth Edition. Pearson, 2009.
5	Mike Markel. "Practical Strategies for Technical Communication," Bedford/ St. Martin's Second Edition, 2016
6	Laura J. Gurak and John M. Lannon. "Strategies for Technical Communication in the Workplace," Pearson, 2013.

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence

Integrated B.Tech.+M.Tech. I (AI) Semester – I ELECTRICAL NETWORK ANALYSIS EE103	Scheme	L	T	P	Credit
		3	0	2	04

1.	**Course Outcomes (COs):** **At the end of the course, students will be able to**
CO1	acquire knowledge about AC circuits, electrical network basics, transforms, wave form representation.
CO2	apply the fundamentals of electrical network basics to analyse different networks.
CO3	analyse electrical network using different theorems and different wave forms.
CO4	evaluate network performance using different parameters.
CO5	design and analyse different types of systems using network principles and network theorems.

2.	**Syllabus**	
	AC FUNDAMENTALS AND CIRCUITS	**(07 Hours)**
	Alternating Voltages and Currents through Purely Resistive Inductive and Capacitive Circuits, R-L, R-C, R-L-C Series Circuits, Impedance and Admittance, Circuits in Parallel, Series and Parallel Resonance, Complex Algebra and its Application to Circuit Analysis, Circuit Transient, Initial and Final Value Theorem, DC and Induction Machines, Electrical Measurements, Power System.	
	POLYPHASE CIRCUITS AND TRANSFORMES	**(05 Hours)**
	Balanced Three Phase Systems, Star and Mesh Connections, Relation between Line and Phase Quantities, Measurement of Power, Principle of Transformer, Construction, Transformer on no-load and with load, Phasor Diagram for Transformer under No-Load and Loaded Condition (with unity, lagging power factor load) Equivalent Circuit, Open Circuit and Short Circuit Test, Efficiency, Voltage Regulation.	
	NETWORK CONCEPTS	**(04 Hours)**
	Network Element Symbols and Conventions, Active Element Conventions, Current and Voltage Conventions, Loops and Meshes, Nodes, Coupled circuits and Dot Conventions.	
	MESH CURRENT AND NODE VOLTAGE NETWORK ANALYSIS	**(07 Hours)**
	Kirchhoff's Voltage Law, Kirchhoff's Current Law, Definitions of Mesh Current and Nodal Voltage, Choice of Mesh Currents or Nodal Voltages for Network Analysis, Self and Mutual Inductances, Mesh Equation in the Impedance Matrix Form by Inspection, Solution of Linear Mesh Equations, Nodal Voltage Analysis Nodal Equations in the Form of Admittance Matrices by Inspection, Solution of Linear Nodal Equations.	

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	NETWORK THEOREMS AND GRAPH	**(08 Hours)**
	Linearity and Superposition, Independent and Dependent Source and their Transformations, Thevenin, Norton, Reciprocity and Maximum Power Transfer Theorems, Use of these Theorems in Circuit Analysis, Duality and Dual of a Planner Network, Fundamental Concepts, Definition of Graph and Various Related Terms, Paths and Circuits Connections, Tree of a Graph, Cut Sets and Tie Sets, Non-separable Planner and Dual Graphs, Matrices of Oriented Graphs, Properties and Inter-Relationship of Incidence, Tie Set and Cut Set Matrices, Complete Analysis Using Tie Set and Cut Set Matrices.	
	WAVE FORM ANALYSIS BY FOURIER SERIES	**(06 Hours)**
	Trigonometric and Complex Exponential Forms, Frequency Spectra of Periodic Wave Forms, Fourier Integral and Continuous Frequency Spectra, Fourier Transform and their Relationship with Laplace Transform.	
	NETWORK FUNCTIONS AND TWO PORT PARAMETERS	**(08 Hours)**
	Poles and Zeros of a Function, Physical and Analytical Concepts, Terminal and Terminal Pairs, Driving Point Immitances, Transfer Functions, Definitions, Calculations and Interrelationship of Impedance, and Admittance, Hybrid and Transmission Line Parameters for four Terminal Networks. Image Impedance and its Calculations for Symmetrical and Unsymmetrical π, T and Ladder Networks.	
	Practicals will be based on the coverage of the above topics separately.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

3.	**Practicals**
1	To study Ammeter and Voltmeter for current and voltage measurement in circuit.
2	To study Energy meter.
3	Verification of superposition theorem for electric circuit.
4	To study Power measurement method for three phase circuits using watt meter method.
5	Verification of Thevenin's theorem of electric circuit.
6	Calculation and verification Norton's theorem.
7	Open circuit and short circuit test for the transformers for efficiency calculation.
8	Verification of Kirchhoff's current law and Kirchhoff's voltage law for electric circuit.
9	Capacitance measurement of parallel plates.
10	Calculation of efficiency of auto transformer.

4.	**Books Recommended**

1.	W.H.Hyat, J.E.Kemmerly, S.M.Durbin, "Engineering Circuit Analysis", 6th Edition, TMH, 2006.
2.	Van Valkenburg M E, "Network Analysis", 3rd Edition, PHI, 2002.
3.	Samarjit Ghosh, "Network Theory, Analysis & Synthesis", 3rd Edition, PHI, 2005.
4.	C.L.Wadhwa, "Network Analysis & Synthesis", Revised 3rd Edition, New Age International Publishers, 2007.
5.	Kothari and Nagrath, "Basic Electrical Engineering", 2nd edition, Tata McGraw-Hill Education, 2007.

ADDITIONAL REFERENCE BOOKS	
1.	V. N. Mittle & Arvind Mittal, "Basic Electrical Engineering", 2nd edition, Tata McGraw-Hill Education, 2005.

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

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Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence

Integrated B.Tech.+M.Tech. I (AI) Semester – II DATA STRUCTURES IA102	Scheme	L	T	P	Credit
		3	1	2	05

1.	**Course Outcomes (COs):** **At the end of the course, the students will be able to**
CO1	recognize the need of different data structures and understand its characteristics.
CO2	apply different data structures for given problems.
CO3	design and analyse different data structures, sorting and searching techniques.
CO4	evaluate data structure operations theoretically and experimentally.
CO5	give solution for complex engineering problems.

2.	**Syllabus**	
	INTRODUCTION TO DATA STRUCTURES	**(03 Hours)**
	Review of Concepts: Information and Meaning, Abstract Data Types, Internal Representation of Primitive Data Structures, Arrays, Strings, Structures, Pointers.	
	LINEAR LISTS	**(06 Hours)**
	Sequential and Linked Representations of Linear Lists, Comparison of Insertion, Deletion and Search Operations for Sequential and Linked Lists, Doubly Linked Lists, Circular Lists, Lists in Standard Template Library (STL), Applications of Lists.	
	STACKS	**(06Hours)**
	Sequential and Linked Implementations, Representative Applications such as Recursion, Expression Evaluation Viz., Infix, Prefix and Postfix, Parenthesis Matching, Towers of Hanoi, Wire Routing in a Circuit, Finding Path in a Maze.	
	QUEUES	**(06 Hours)**
	Operations of Queues, Circular Queue, Priority Queue, Dequeue, Applications of Queues, Simulation of Time Sharing Operating Systems, Continuous Network Monitoring System Etc.	
	SORTING AND SEARCHING	**(04 Hours)**
	Sorting Methods, Bubble Sort, Selection Sort, Quick Sort, Radix Sort, Bucket Sort, Dictionaries, Hashing, Analysis of Collision Resolution Techniques, Searching Methods, Linear Search, Binary Search, Character Strings and Different String Operations.	

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

	TREES	**(08 Hours)**
	Binary Trees and Their Properties, Terminology, Sequential and Linked Implementations, Tree Traversal Methods and Algorithms, Complete Binary Trees, General Trees, AVL Trees, Threaded Trees, Arithmetic Expression Evaluation, Infix-Prefix-Postfix Notation Conversion, Heaps as Priority Queues, Heap Implementation, Insertion and Deletion Operations, Heapsort, Heaps in Huffman Coding, Tournament Trees, Bin Packing.	
	MULTIWAY TREES	**(05 Hours)**
	Issues in Large Dictionaries, M-Way Search Trees, BTrees, Search, Insert and Delete Operations, Height of B-Tree, 2-3 Trees, Sets and Multisets in STL.	
	GRAPHS	**(07 Hours)**
	Definition, Terminology, Directed and Undirected Graphs, Properties, Connectivity in Graphs, Applications, Adjacency Matrix and Linked Adjacency Chains, Graph Traversal, Breadth First and Depth First Traversal, Spanning Trees, Shortest Path and Transitive Closure, Activity Networks, Topological Sort and Critical Paths.	
	Tutorials will be based on the coverage of the above topics separately	**(15 Hours)**
	Practicals will be based on the coverage of the above topics separately	**(30 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours + 30 Hours = 90 Hours)	

3.	**Tutorials**
1	Problems on Array
2	Problems on Stack and Queue
3	Problems on Linked List
4	Problems on Trees
5	Problems on Graph

4.	**Practical**
1	Implementation of Array and its applications
2	Implementation of Stack and its applications
3	Implementation of Queue and its applications

4	Implementation of Link List and its applications
5	Implementation of Trees and its applications
6	Implementation of Graph and its applications
7	Implementation of Hashing functions and collision resolution techniques
8	Mini Project (Implementation using above Data Structure)

5.	Books Recommended
1	Trembley & Sorenson: "An Introduction to Data Structures with Applications", 2/E, TMH, 1991.
2	Tanenbaum & Augenstein: "Data Structures using C and C++", 2/E, Pearson, 2007.
3	Horowitz and Sahani: "Fundamentals of Data Structures in C", 2/E, Silicon Press, 2007.
4	T. H. Cormen, C. E. Leiserson, R. L. Rivest: "Introduction to Algorithms",3/E, MIT Press, 2009.
5	Robert L. Kruse, C. L. Tondo and Brence Leung: "Data Structures and Program Design in C", 2/E, Pearson Education, 2001.

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence

Integrated B.Tech.+ M.Tech. I (AI) Semester – II WEB PROGRAMMING AND PYTHON IA104	Scheme	L	T	P	Credit
		3	0	2	04

1.	Course Outcomes (COs): At the end of the course, students will be able to
CO1	acquire knowledge about the basics of web pages, need of web server, configuration, client and server side scripting, style of web pages and script programming.
CO2	install and configure the web server and apply the knowledge of programming to develop web application pages using html, style sheets, client and server side scripts using script programming.
CO3	analyse given problem for the requirement of html, style sheets, client side or server side script with different programming constructs.
CO4	evaluate web application programming solutions with different aspects like the presentation and working of the web application and usage of different scripting constructs.
CO5	utilize the standard tools for design and development of web project solution for given problems by integrating html, client and server pages with style and scripting.

2.	Syllabus	
	INTRODUCTION	**(03 Hours)**
	Basics of Internet, World Wide Web, HTTP Protocol, Universal Resource Locator, Web Server, Different Types of Web Servers, Domain Name Server, Web Server Configuration, Internet Browser, Web Document and Mark-Up Language, Hypertext Mark-Up Language, Hypermedia, Web Site Organization, Content Organization, Web Server on Different Operating System Platforms, Web Applications, Web Interface, Web Standards & Accessible Design.	
	STATIC AND DYNAMIC WEB PAGES, STYLE SHEETS AND WEB PUBLISHING	**(17 Hours)**
	Web Page, Static Web Page, Hypertext Mark-Up Tags, Handling Font Style, Types, Size, Colour Etc., Handling Table, List, Images, Graphics, Menu Etc; Forms, Input Text Box, Drop Down Menu, Name Variable, Cookie Management, Session Management, Animation, Structure Web Pages, Image Mapping, Link Setup In Image, Frames, Structuring Web Pages Using Frames, Multimedia Handling, Linking To Pages; Dynamic Web Pages and Scripting - Scripting Language, Dynamic Pages and Forms Validation, Validation of Input Text Box, Dynamic Drop Down Menu, Validation and Accessing Name Variable-Value Pair, Cookie Management Through Scripting, Session Management through Scripting, Animation through Scripting, Dynamic Image Mapping Through Scripting, Link Handling through Scripting, Multimedia Handling through Scripting; Web Page Designing using Style Sheet, Different Types of Style Sheet, Defining Different Styles, Export and Importing Style Sheet, Cascade Style Sheet. Web Hosting and Publishing - Different Steps of Web Hosting and Publishing, Documents Interchange Standards, Website Evaluation, Components of Web Publishing, Document Management, Search	

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	Engines, and Registration of a Web Site on Search Engines, Publishing Tools.	
	PYTHON PROGRAMMING	**(25 Hours)**
	Basics of Python Programming: Variables, Keywords, Expressions, Data Types, Operators and Operands, Assignments, Order of Operations, Controlling Statements, Branching and Loops, Functions, Definitions, Arguments, Returning Values, Scopes, Recursive Functions, Modules and Import, Strings, Tuples, and Lists; Handling Exceptions – Try/Except, Standard Exceptions, Exceptions as Control Flow Mechanisms; Object Oriented Programming – Classes, Abstract Data Types, Inheritance, Encapsulation; Debugging – Syntax errors, Runtime Errors, Semantic Errors, Test Cases; Files – Reading, Iterating over Lines, Finding a File in File system, Writing Data to Files, CSV Format, Read and Write To/From CSV File; Dictionaries – Introduction, Dictionary Operations, Aliasing, Copying, Dictionary Accumulation, Introduction to Module Packages.	
	Practicals will be based on the coverage of the above topics.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

3.	Practicals
1	To prepare the web page using hypertext markup language
2	To study and setup the web server for implementation
3	To learn client side scripting
4	To learn server side scripting
5	To apply style to the web pages
6	To implement functions for files
7	To implement dictionary

4.	Books Recommended
1	Martin C. Brown, "Python: The Complete Reference, Osborne, McGraw-Hill, 2018.
2	Thomas Powell and fritz Schneider, "JavaScript: The Complete Reference, McGraw-Hill, 2017.
3	J. Sklar, "Principles of Web Design", 7/E, Cengage Learning, 2017.
4	H. Deitel, A. Deitel, "Internet and World Wide Web How to Program", 5/E, Pearson, 2012.
5	John V. Guttag, "Introduction to Computation and Programming Using Python", MIT Press, 2013 Edition.

ADDITIONAL REFERENCE BOOKS

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

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1	Martin C. Brown, "Python: The Complete Reference, Osborne, McGraw-Hill, 2018.
2	1. M. L. Young," The Complete reference of Internet", Tata Mc Graw Hill, 2002.
3	2. W. G. Lehnert, "Internet 101, 1/E, Person Education, 2001.
4	B. Underdahle and K. Underdahle, "Internet and Web Page/ Website design", 2/E, IDG Books India (P) Ltd., 2001.
5	D. Comer, "The Internet Books," Prentice Hall of India, 2/E, 2001.

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Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence

Integrated B.Tech.+M.Tech. I (AI) Semester – II ENERGY AND ENVIRONMENTAL ENGINEERING EG110	Scheme	L	T	P	Credit
		3	0	2	04

1.	**Course Outcomes (COs):** **At the end of the course, students will be able to**
CO1	Explain the components of ecosystems, various biogeochemical cycles and importance of different urban network services
CO2	Differentiate between various types of environmental pollution along with their impacts and regulatory standards
CO3	Examine various global environmental issues and their management
CO4	Discuss the fundamental principles of energy, including classification, conservation and related policy frameworks and regulations.
CO5	Get acquainted with the concept of energy systems and their components

2.	**Syllabus**	
	ENVIRONMENT AND ECOSYSTEMS	**(10 Hours)**
	Introduction: Concept of an ecosystem - structure and functions of ecosystem; Components of ecosystem - producers, consumers, decomposers; Food chains, food webs, ecological pyramids, energy flow in ecosystem; Bio-geochemical cycles, hydrologic cycle Components of environment and their relationship, impact of technology on environment, environmental degradation, environmental planning of urban network services such as water supply, sewerage, solid waste management; closed loop cycle, concepts of sustainability	
	ENVIRONMENTAL POLLUTION	**(10 Hours)**
	Water, air, soil, noise, thermal and radioactive, marine pollution - sources, effects and engineering control strategies; Centralized and decentralized treatment system, Drinking water quality and standards, ambient air and noise standards	
	GLOBAL ENVIRONMENTAL ISSUES AND ITS MANAGEMENT	**(10 Hours)**
	Engineering aspects of climate change, concept of carbon credit, CO_2 sequestration, concepts of environmental impact assessment and environmental audit, life cycle assessment	
	BASICS OF ENERGY AND ITS CONSERVATION	**(07 Hours)**
	Classification of energy sources, Global and national energy scenario, Fossil and alternate fuels and its characterization. General aspects of energy conservation and management; Energy conservation act,	

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	Energy policy of company; Need for energy standards and labelling; Energy building codes.	
	INTRODUCTION TO ENERGY CONSERVATION SYSTEMS	**(08 Hours)**
	Energy conversion systems: Working principle, Basic components, General functioning and normal rating specifications of various energy conversion systems like Power plant, Pump, Refrigerator, Air-conditioner, Internal combustion engine, Solar PV cell, Solar water heating system, Biogas plant. Wind turbine, Fuel cells.	
	Practicals will be based on the coverage of the above topics separately.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

3.	**Practical**
1	Performance Test on a computerised single cylinder diesel engine
2	Performance Test on Three-cylinder petrol engine
3	Determination of COP of vapor compression refrigeration system
4	Study of General Motors Cruze Vehicle Automotive System
5	Study of MG Hector Vehicle Automotive Systems
6	Measurement of direct and diffused Solar radiation using pyranometer
7	Determination of I-V Characteristics of solar PV Panel
8	Study of electricity and or gas bill
9	Study of pollutants from diesel Engine
10	Study of pollutants from petrol Engine

4.	**Books Recommended**
1	Daniel B. Botkin & Edward AKeller, Environmental Sciences, John Wiley & Sons.
2	R. Rajagopalan, Environmental Studies, Oxford University Press.
3	Benny Joseph, Environmental Studies, TMH Publishers.
4	Dr. Suresh K. Dhameja, Environmental Studies, S. K. Kataria & Sons, 2007.
5	U. K. Khare, Basics of Environmental Studies, Tata McGraw Hill, 2011.

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

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ADDITIONAL REFERENCE BOOKS	
1	C. S. Rao, Environmental Pollution Control Engineering, New Age International Publishers, 2018

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Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence

Integrated B.Tech.+M.Tech. I (AI) Semester – II DISCRETE MATHEMATICS MA106		L	T	P	Credit
	Scheme	3	1	0	04

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	acquire knowledge of sets, group and functions, graphs.
CO2	apply group theory, relations and lattice.
CO3	analyse functions, counting and based on mathematical logic.
CO4	evaluate formal verification of computer programmes.
CO5	design solutions for various types of problems in different disciplines like information security, optimization, mathematical analysis.

2.	**Syllabus**	
	Introduction	**(04 Hours)**
	Introduction to set theory, Basics of functions, Application of Functions in Computer Science Areas.	
	GROUP THEORY	**(08 Hours)**
	Basic Properties of Group, Groupoid, Semigroup & Monoid, Abelian Group, Subgroup, Cosets, Normal Subgroup, Lagrange's Theorem, Cyclic Group, Permutation Group, Homomorphism & Isomorphism of Groups, Basic Properties, Error Correction & Detection Code.	
	RELATION & LATTICES	**(06 Hours)**
	Definition & Basic Properties, Graphs Of Relation, Matrices Of Relation, Equivalence Relation, Equivalence Classes, Partition, Partial Ordered Relation, Posets, Hasse Diagram, Upper Bounds, Lower Bound, GLB & LUB Of Sets, Definition & Properties Of Lattice, Sub Lattice, Distributive & Modular Lattices, Complemented & Bounded Lattices, Complete Lattices & Boolean Algebra.	
	MATHEMATICAL LOGIC AND PROGRAM VERIFICATION	**(06 Hours)**
	Induction, Propositions, Combination Of Propositions, Logical Operators & Propositional Algebra, Equivalence, Predicates & Quantifiers, Interaction of Quantifiers with Logical Operators, Logical Interference & Proof Techniques, Formal Verification of Computer Programs (Elements of Hoare Logic).	
	COUNTING AND RECURRENCE RELATION	**(06 Hours)**
	First Counting Principle, Second Counting Principle, Permutation, Circular Permutations, Combination, Pigeonhole Principle, Recurrence Relations, Linear Recurrence Relations, Inclusion And Exclusion, Generating Functions.	

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

	BASICS OF GRAPHS	**(05 Hours)**
	Graph Definition, Graph Representation, Basic Concepts Of Finite & Infinite Graph, Incidence & Degree, Isomorphism, Subgraph, Walk, Path & Circuits, Cliques, Cycles and Loops, Operations On Graphs, Connected Graph, Disconnected Graph & Components, Complete Graph, Regular Graph, Bipartite Graph, Planar Graphs, Weighted Graphs, Directed & Undirected Graphs, Connectivity Of Graphs.	
	GRAPHS ALGORITHMS	**(10 Hours)**
	Flows, Combinatorics, Euler's Graph, Hamiltonian Paths & Circuits, Activity Planning and Critical Path, Planar Graphs: Properties, Graph Coloring, Vertex Coloring, Chromatic Polynomials, Edge Coloring, Planar Graph Coloring, Matching and Factorizations: Maximum Matching In Bipartite Graphs, Maximum Matching In General Graphs, Hall's Marriage Theorem, Factorization; Networks: Max-Flow Min-Cut Theorem, Menger's Theorem, Graph and Matrices; Probabilistic Graphical Models:Graphical models, Directed models: Bayesian network, Undirected model: Markov Random Fields, Dynamic model: Hidden Markov Model, Learning in Graphical models: Parameter estimation, Expectation Maximization.	
	Tutorials will be based on the coverage of the above topics separately	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3. Tutorials:

1. Problem solving on group theory.
2. Problem solving on relation and lattices.
3. Problem solving on mathematical logic and program verification.
4. Problem solving on counting and recurrence relation.
5. Problem solving on basics of graphs.
6. Problem solving on graph algorithms.

3. Books Recommended:

1. Rosen K.H., "Discrete Mathematics and Its Applications", 6/E, MGH, 2006.
2. Liu C.L., "Elements of Discrete Mathematics", MGH, 2000.
3. Deo Narsingh., "Graph theory with applications to Engineering & Computer Science", PHI, 2000.
4. J. A.Bondy and U. S. R.Murty, "Graph Theory", Springer, 2008.
5. V. K. Balakrishnan, "Theory and Problems of Graph Theory", Tata McGraw-Hill, 2007.

ADDITIONAL REFERENCE BOOKS

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

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1. Kolman B., Busby R.C. & Ross S., "Discrete Mathematical Structure", 5/E, PHI, 2003.
2. Tremblay J. P. & Manohar R., "Discrete Mathematical structure with applications to computer science", MGH, 1999.
3. D. B. West, "Introduction to Graph Theory", 2nd Edition, PHI 2002.
4. G. Chatrand and O.R. Ollermann, "Applied and Algorithmic Graph Theory", McGraw Hill, 1993.

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Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence

Integrated B.Tech.+M.Tech. I (AI) Semester – II DIGITAL ELECTRONICS AND LOGIC DESIGN EC106	Scheme	L	T	P	Credit
		3	0	2	04

1.	**Course Outcomes (COs):** **At the end of the course, students will be able to**
CO1	acquire knowledge about different types of diodes and circuits.
CO2	apply the knowledge of gates, Boolean algebra and operational amplifier in designing logical and integrated circuits.
CO3	analyse the logical, integrated, and operational amplifier based circuits.
CO4	evaluate the different circuits and compare their performance.
CO5	design ALU and control unit.

2.	**Syllabus**	
	PN DIODE AND TRANSITOR	**(07 Hours)**
	PN Diode Theory, PN Characteristic and Breakdown Region, PN Diode Application as Rectifier, Zener Diode Theory, Zener Voltage Regulator, Diode as Clamper and Clipper, Photodiode Theory, LED Theory, 7 Segment LED Circuit Diagram and Multi Colour LED, LASER Diode Theory and Applications, Bipolar Junction Transistor Theory, Transistor Symbols And Terminals, Common Collector, Emitter and Base Configurations, Different Biasing Techniques, Concept of Transistor Amplifier, Introduction to FET Transistor And Its Feature.	
	WAVESHAPING CIRCUITS AND OPERATIONAL AMPLIFIER	**(06 Hours)**
	Linear Wave Shaping Circuits, RC High Pass and Low Pass Circuits, RC Integrator and Differentiator Circuits, Nonlinear Wave Shaping Circuits, Two Level Diode Clipper Circuits, Clamping Circuits, Operational Amplifier OP-AMP with Block Diagram, Schematic Symbol of OP-AMP, 741 Package Style and Pinouts, Specifications of Op-Amp, Inverting and Non-Inverting Amplifier, Voltage Follower Circuit, Multistage OP-AMP Circuit, OP-AMP Averaging Amplifier, OP-AMP Subtractor.	
	BOOLEAN ALGEBRA AND SWITCHING FUNCTIONS	**(04 Hours)**
	Basic Logic Operation and Logic Gates, Truth Table, Basic Postulates and Fundamental Theorems of Boolean Algebra, Standard Representations of Logic Functions- SOP and POS Forms, Simplification of Switching Functions-K-Map and Quine-Mccluskey Tabular Methods, Synthesis of Combinational Logic Circuits.	
	COMBINATIONAL LOGIC CIRCUIT USING MSI INTEGRATED CIRCUITS	**(07 Hours)**
	Binary Parallel Adder; BCD Adder; Encoder, Priority Encoder, Decoder; Multiplexer and Demultiplexer Circuits; Implementation of Boolean Functions Using Decoder and Multiplexer; Arithmetic and Logic	

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	Unit; BCD to 7-Segment Decoder; Common Anode and Common Cathode 7-Segment Displays; Random Access Memory, Read Only Memory and Erasable Programmable ROMS; Programmable Logic Array (PLA) and Programmable Array Logic (PAL).	
	INTRODUCTION TO SEQUENTIAL LOGIC CIRCUITS	**(04 Hours)**
	Basic Concepts of Sequential Circuits; Cross Coupled SR Flip-Flop Using NAND or NOR Gates; JK Flip-Flop Rise Condition; Clocked Flip-Flop; D-Type and Toggle Flip-Flops; Truth Tables and Excitation Tables for Flip-Flops; Master Slave Configuration; Edge Triggered and Level Triggered Flip-Flops; Elimination of Switch Bounce using Flip-Flops; Flip-Flops with Preset and Clear.	
	SEQUENTIAL LOGIC CIRCUIT DESIGN	**(06 Hours)**
	Basic Concepts of Counters and Registers; Binary Counters; BCD Counters; Up Down Counter; Johnson Counter, Module-N Counter; Design of Counter Using State Diagrams and Table; Sequence Generators; Shift Left and Right Register; Registers with Parallel Load; Serial-In-Parallel-Out (SIPO) And Parallel-In-Serial-Out (PISO); Register using Different Type of Flip-Flop.	
	REGISTER TRANSFER LOGIC	**(04 Hours)**
	Arithmetic, Logic and Shift Micro-Operation; Conditional Control Statements; Fixed-Point and Floating-Point Data; Arithmetic Shifts; Instruction Code and Design Of Simple Computer.	
	PROCESSOR LOGIC DESIGN	**(03 Hours)**
	Processor Organization; Design of Arithmetic Logic Unit; Design of Accumulator.	
	CONTROL LOGIC DESIGN	**(04 Hours)**
	Control Organization; Hard-Wired Control; Micro Program Control; Control Of Processor Unit; PLA Control.	
	Practicals will be based on the coverage of the above topics separately.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

3.	Practicals
1	Study of BJT Characteristics
2	Study of CE Amplifier
3	Study of RC Coupled / Tuned Amplifier
4	Study of FET Characteristics
5	Study of Diode Clipper Circuits
6	Study of Diode Clamper Circuits
7	Study and Implement RC Low Pass and High Pass Filter Circuits

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

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8	Study and Implement RC Integrator Circuits
9	Study and Implement RC Differentiator Circuits
10	Full and Half-Adder/ Half-subtarctor Circuits using a serial Input
11	4-Bit Gray to Binary/ Binary to Gray Code convertor using Select input
12	Logic expression with the Help of MUX IC 74153
13	Flip-flops using NAND/ NOR Gate
14	Modulo-7 Ripple Counter
15	4-Bit Shift Left/Right Register
16	Sequence Generator

4.	**Books Recommended**
1	Schilling Donald L. and Belove E., "Electronics Circuits- Discrete and Integrated", 3rd Ed., McGraw-Hill, 1989, Reprint 2008.
2	Millman Jacob, Halkias Christos C. and Parikh C., "Integrated Electronics", 2nd Ed., McGraw-Hill, 2009.
3	Taub H. and Mothibi Suryaprakash, Millman J., "Pulse, Digital and Switching Waveforms", 2nd Ed., McGraw-Hill, 2007.
4	Mano Morris, "Digital Logic and Computer Design", 5th Ed., Pearson Education, 2005.
5	Lee Samual, "Digital Circuits and Logic Design", 1st Ed., PHI, 1998.

ADDITIONAL REFERENCE BOOKS	
1	Malvin Albert & David J. Bates, "Electronic Principles", 7th edition, Tata McGraw Hill, 2007.
2	De Debashis, "Basic of Electronics", 1st Ed., Pearson Education, 2008.
3	Floyd and Jain, "Digital Fundamentals", Pearson Education, 2006.

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Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence

Integrated B.Tech.+M.Tech. I (AI) Semester – II INDIAN VALUE SYSTEM AND SOCIAL CONSCIOUSNESS HS120	Scheme	L	T	P	Credit
		2	0	0	02

1.	Course Outcomes (COs): At the end of the course, the students will be able to
CO1	interpret the important values that need to be cultivated
CO2	analyse the cultures depicted in Ramayana, Mahabharata, Jainism and Buddhism
CO3	review the structure of Indian knowledge system
CO4	discuss the significance of constitution of India
CO5	demonstrate social responsibility

2.	Syllabus	
	HUMAN VALUES AND CONSCIOUSNESS	**(08 Hours)**
	Human Values Definition and Classification of Values; The Problem of Hierarchy of Values and their Choice; Self-Exploration; 'Basic Human Aspirations; Right understanding, Relationship and Physical Facility; fulfilment of aspirations; Understanding Happiness and Prosperity, Harmony at various levels. What Is Consciousness? ; Can We Build A Conscious Machine?; Levels Of Consciousness; Mind, Matter And Beyond; Holistic Lifestyle; Dealing With Anxiety; Connecting Mind To Brain; Minds, Brains, And Programs.	
	INDIAN CULTURE AND HERITAGE	**(07 Hours)**
	Culture and its salient features: The Vedic – Upanishadic Culture and society, Human aspirations in those societies; Culture in Ramayana and Mahabharata: The Ideal Man and Woman, Concepts Maitri, Karuna, Seela, Vinaya, Kshama, Santi, Anuraga – as exemplified in the stories and anecdotes of the Epics; The Culture of Jainism: Jaina conception of Soul, Karma and liberation, Buddhism as a Humanistic culture; The four Noble truths of Buddhism; Vedanta and Indian Culture;	
	INDIAN KNOWLEDGE SYSTEM	**(08 Hours)**
	Indian knowledge as a unique system, Place of Indian knowledge in mankind's evolution, Relevance of Indian knowledge to present day and future of mankind, Nature of Indian Knowledge; Structure of Indian Knowledge: Types of knowledge (para, apara), The scientific and the unscientific, Instruments for gaining and verifying knowledge, Knowledge traditions: Lineages, Instruments - debate, epistemology and pedagogy, The inverted tree – axiomatic, deductive, empirical knowledge, and evolution of knowledge; Disciplines of Study: A brief outline of the subjects, the major contributions and theories along with timelines where relevant: Mathematics;	

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

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	Astronomy; Physical Sciences; Cosmogony; Language studies; Astrology; Moral studies/righteousness; Statecraft and political philosophy	
	INDIAN CONSTITUTION	**(04 hours)**
	History of Making of the Indian Constitution; Philosophy of the Indian Constitution: Preamble; Salient Features; Contours of Constitutional Rights & Duties; Organs of Governance: Parliament; Composition; Qualifications and Disqualifications; Powers and Functions	
	SOCIAL RESPONSIBILITY	**(03 Hours)**
	Social Responsibility: Meaning and Importance, Different Approaches of Social Responsibility. Social Responsibility of Business towards different Stakeholders. Evolution and Legislation of CSR in India.	
		(Total Contact Time: 30 Hours)

3.	**Books Recommended**
1	D. K. Chaturvedi, Professional Ethics Values and Consciousness, Ane Books Pvt. Ltd., 2023.
2	R.R. Gaur, R Sangal, G. P. Bagaria, Human Values and Professional Ethics, Excel Books, New Delhi, 2010.
3	A.N. Tripathi, Human Values, New Age Intl. Publishers, New Delhi, 2004.
4	P R Rao, Indian Heritage and Culture, Sterling Publishers Pvt. Ltd, 1988.
5	D. Singh, Indian Heritage and Culture, APH Publishing Corporation, 1998.
6	Sri Prashant Pole, Treasure Trove of Indian knowledge, Prabhat Prakashan, 2021.
7	Sri Suresh Soni, Sources of our cultural heritage, Prabhat Prakashan, 2018.
8	D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

Department of Artificial Intelligence
M.Tech in Data Science & Business Intelligence

Teaching Scheme

Sr. No.	Subject	Code	Scheme L-T-P	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
				Th	T	P		
				Marks	Marks	Marks		
	First Semester							
1	Core subject – 1 Probability and Statistics		3-1-0	100	25	0	4	75
2	Core Subject – 2 Linear algebra & optimization		3-1-0	100	25	0	4	75
3	Core subject – 3 Machine Learning		3-0-2	100	0	50	4	100
4	Elective -1		3-0-2	100	-	50	4	100
5	Elective - 2		3-1-0	100	25	-	4	100
				Total			**20**	**450**
6	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)		0-0-10				5	200 (20 x 10)
	Second Semester							
1	Core subject – 4 Big data Analysis & Visualization		3-0-2	100	-	50	4	100
2	Core Subject – 5 Deep Learning		3-0-2	100	-	50	4	100
3	Elective -3		3-1-0	100	25	-	4	75
4	Elective -4		3-1-0	100	25	-	4	75
5	Institute Elective*		3-0-0	100	-	-	3	55
6	Mini Project		0-0-4	-	-	100	2	70
						Total	**21**	**475**
7	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)		0-0-10				5	200 (20 x 10)

Sr. No.	Subject	Code	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
			Th. Marks	T Marks	P Marks		
	Third Semester						
1	MOOC course – I*		-	-	-	3/4[φ]	70/80
2	MOOC course – II*		-	-	-	3/4[φ]	70/80
3	Dissertation Preliminaries		-	-	350[$]	14	560
			Total			**20-22**	**700-720**
	Fourth Semester						
1	Dissertation		-	-	600[$]	20	800

[$] **Internal**: 40% and **External**: 60%

*Swayam/NPTEL

φAs per 66^{th} IAAC, Dated 20^{th} March, 2024, Resolution No. 66.34 and 61^{st} Senate resolution No. 4, 25^{th} April, 2024.

Praveen,

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence
M.Tech. Artificial Intelligence and Machine Learning

		L	T	P	Credit
M. Tech. (AI&ML) **Probability and Statistics** **AIYYY**	**Scheme**	3	0	2	04

1. Course Outcomes (COs): **At the end of the course, students will be able to**	
CO1	To provide mathematical background and sufficient experience so that student can read, write and understand sentences in the language of probability theory.
CO2	To introduce students to the basic methodology of "probabilistic thinking" and apply it to problems.
CO3	To understand basic concepts of Probability theory and Random Variables, how to deal with multiple Random Variables.
CO4	To understand the difference between time averages statistical averages.
CO5	To teach students how to apply sums and integrals to compute probabilities, and expectations.

2.	Syllabus	
	Basic of Probability	(6 Hours)
	Introduction, Axioms of Probability & its properties, Joint Probability, Marginal Probability, Conditional Probability, Bayes Theorem, Independence of Events, Total Probability theorem, Central limit theorem, Chain Rule of Conditional Probabilities	
	Random Variables and Probability Distributions	(8 Hours)
	Distribution Functions of Discrete Variables: Bernoulli Distribution Binomial Distribution Geometric Distribution, Poisson distribution, Distribution Functions of Continuous Variables: Uniform, Exponential, Normal (Gaussian), Gamma Distribution. Mean, Variance of Random Variables & higher order moments, Expectation of function of Random variables, Characteristic, Functions, Chebychev Inequality.	
	Multivariate Random Variables	(8 Hours)
	Bivariate Discrete Random Variables. Bivariate Continuous Random Variables. Conditional Distributions. Independence of Random Variables, Multivariate Random variables, Joint, Marginal, and conditional PMF, PDF, and CDF.	
	Product Moments of Bivariate Random Variables	(4 Hours)
	Covariance of Bivariate Random Variables, Independence of Random Variables, Variance of the Linear, Combination of Random Variables, Correlation and Independence.	
	Sampling Theory	(8 Hours)

	Population and Sample. Statistical Inference Sampling With and Without Replacement Random Samples. Random Numbers Population Parameters. Sample Statistics, Sampling Distributions, Sample Mean, Sampling Distribution of Means, Sampling Distribution of Proportions, Sampling Distribution of Differences and Sums, Sample Variance, Sampling Distribution of Variances, Case Where Population Variance Is Unknown Sampling Distribution of Ratios of Variances Other Statistics Frequency Distributions Relative Frequency Distributions Computation of Mean, Variance, and Moments for Grouped Data	
	Estimation Theory	**(5 Hours)**
	Unbiased Estimates and Efficient Estimates Point Estimates and Interval Estimates. Reliability Confidence Interval Estimates of Population Parameters Confidence Intervals for Means Confidence Intervals for Proportions Confidence Intervals for Differences and Sums Confidence Intervals for the Variance of a Normal Distribution Confidence Intervals for Variance Ratios Maximum Likelihood Estimates	
	Tests of Hypotheses and Significance	**(5 Hours)**
	Statistical Decisions Statistical Hypotheses. Null Hypotheses Tests of Hypotheses and Significance Type I and Type II Errors Level of Significance Tests Involving the Normal Distribution One-Tailed and Two-Tailed Tests PValue Special Tests of Significance for Large Samples Special Tests of Significance for Small Samples Relationship Between Estimation Theory and Hypothesis Testing Operating Characteristic Curves. Power of a Test Quality Control Charts Fitting Theoretical Distributions to Sample Frequency Distributions The Chi-Square Test for Goodness of Fit.	
	(Total Contact Time: 45 Hours + 15 Hours =60 Hours)	

4 Tutorial:	
	1. Analytical and real world problem on basic probability
	2. Numerical problems on Bayes theorem
	3. Proof on various probability distribution function
	4. Problem on bivariate probability distribution function
	5. Problem on Multivariate probability distribution function
	6. Derivation on Moment generating function
	7. Real time numerical example on Estimation theory likes weather forecasting, radar transit time etc.
	8. Real time numerical on hypothesis test e.g. Telecom service, online purchase system, election etc
	9. Numerical problem on significance Type 1 and Type 2 error impact on decision making
	10. Numerical problem based on chi-square goodness of fit test on categorical dataset.

Books Recommended:

1. Murray R. Spiegel, John J. Schiller, and R. Alu Srinivasan, Probability and Statistics, Schaum's Outline Series, Mc Graw Hill
2. A. Papoulis & S. U. Pillai, "Probability, Random Variable Variables & Stochastic Processes", 4th Ed,

McGraw Hill Publication, 2016.

3. S. M. Ross, Introduction to Probability Models", Academic Press, 12th Edition, 2019.

REFERENCE BOOKS

4. Gersting J.L., "Mathematical Structure for Computer Science", W.H. Freeman and Co., 3rd Edition, 1993
5. Probability and Statistics for Engineers and Scientists, Ronald E. Walpole, Raymond H. Myers

Praveen,

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence
M.Tech. Artificial Intelligence and Machine Learning

B. Tech. II (AI) Semester – III Linear algebra & optimization AIYYY		L	T	P	Credit
	Scheme	3	0	2	04

1. Course Outcomes (COs): At the end of the course, students will be able to	
CO1	Understand the basic theory of vector spaces: linear independence, spanning, bases, dimension, subspaces
CO2	Understand the basic theory of linear transformations: matrix representation, diagonalisation, orthogonal diagonalisation
CO3	Carry out the basic techniques of the following: row-reduction and LU decomposition to solve systems of linear equations; calculating determinants; finding eigenvalues and eigenvectors and diagonalising matrices; orthogonally diagonalising matrices
CO4	Formulation of single variable and multi variable optimization algorithms to solve engineering problems
CO5	Compute constraints optimization for optimal search methods

.2.	Syllabus	
	Vector Spaces	(6 Hours)
	Vector Space, Subspaces, Linear Span and Linear Dependence, Linear Independence, Basic and Dimension, Linear Functions, Norm of Vector, Affine Functions, Function Composition, System of Linear Equations, Inevitability of Matrices.	
	Least squares and Eigenvalues	(8 Hours)
	Orthogonal Vectors and Subspaces, Projection on Subspace, Triangular Systems, LU Decomposition, QR Decomposition, Matric Norm, Sensitivity Analysis, Condition Number of a Matrix, Least Squares, Least Square data fitting, Classification using Least Squares. Eigenvalues and Eigenvector, Spectral Decomposition Theorem, Positive Definite Matrices	
	Dimensionality reduction	(8 Hours)
	Sensitivity Analysis: Singular Value Decomposition, Properties of SVD, Low Rank Approximations, Principal Component Analysis, SVD and Pseudo-Inverse, SVD and Least Square problem, Power Method	
	Linear Programming problems	(8 Hours)
	Formation of LPP, Feasible solution, Basic feasible solutions, Types of solutions, Graphical method, The Simplex Method, Big M Method, Revised simplex method, Two phase method, Duality and Dual simplex method. Transportation problems, Assignment problems, Travelling Salesman Problem, Shortest Path	

	Algorithms and Network flow problems	
	Unconstrained Problems	**(7 Hours)**
	Convex Sets and Convex Functions, Basic properties of solutions and algorithms, Global convergence. Fibonacci search method, Golden Section Search, Line Search Methods, Steepest Descent and Newton Methods, Modified Newton methods, Globally convergent Newton Method, Nonlinear Least Squares Problem and Algorithms, Conjugate Direction Methods, Trust-Region Methods.	
	Quadratic Programming and Direct Methods	**(8 Hours)**
	Quadratic Programming : Gradient Projection methods and sequential quadratic programming. Dual Methods : Augmented Lagrangians and cutting-plane methods, Penalty and Barrier Methods, Interior Point Methods	
	(Total Contact Time: 45Hours +15 Hours =60 Hours)	

4.	**Tutorial:**
1.	Numerical problem on Vectors operation and Matrices operation.
2.	Linear Transformation problem on generate complex shape from basic shapes.
3.	Matrix factorization problem on recommender system
4.	Positive definitive matrices numerical problem in context to machine learning and finance.
5.	Eigenvalues and Eigenvector based numerical problem for dimensional reduction
6.	Explain how the Singular Value Decomposition used in image compression techniques
7.	Real world numerical problem solution using Transportation
8.	Real world numerical problem solution Travelling Salesman Problem
9.	Primal-Dual and Dual Algorithms for the Assignment and Transportation Problems
10.	Multivariate optimization based case study in data science

5. Books Recommended:

1. David C. Lay, "Linear Algebra and its Applications," 3rd edition, Pearson Education (Asia) Pte. Ltd,2005.

2 Kenneth Hoffman and Ray Kunze, "Linear Algebra," 2nd edition, Pearson Education (Asia) Pte. Ltd/2004.

3. P. E. Gill, W. Murray, and M. H. Wright, Practical Optimization, Academic Press.

4. KalyanmoyDeb,"OptimizationforEngineeringDesign",11th Edition, PHILearning(P), Limited, 2010.

REFERENCE BOOKS

1. Bernard Kolman and David R. Hill, "Introductory Linear Algebra with Applications", Pearson Education

(Asia) Pte. Ltd, 7th edition, 2003.

2. Gilbert Strang, "Linear Algebra and its Applications", 3rd edition, Thomson Learning Asia, 2003.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence

M. Tech. I (AI) Semester –I MACHINE LEARNING AI201		L	T	P	Credit
	Scheme	3	0	2	04

1. **Course Outcomes (COs):** **At the end of the course, students will be able to**	
CO1	To understand the basic concepts, state-of-the art techniques of machine learning, statistical analysis and discriminant functions
CO2	To apply different concepts for the machine learning problems
CO3	To apply and analyze different supervised and unsupervised learning approaches as per the suitability of the problem
CO4	To understand and evaluate machine learning methods to use them
CO5	To design solution of problem using different machine learning approaches

2.	**Syllabus**	
	MATHEMATICS FOR MACHINE LEARNING	**(06 Hours)**
	Multivariate calculus: gradient, Hessian, Jacobian, chain rule; Linear algebra: determinants, eigenvalues/vectors, SVD; Probability theory: conditional probability, marginal probability, Bayes rule	
	INTRODUCTION	**(05 Hours)**
	Introduction to machine learning- Introduction to Machine Learning, Why Machine Learning?, Types, Applications of M/L, Classification and Regression, Data preprocessing and data visualization	
	SUPERVISED LEARNING	**(10 Hours)**
	Local/proximity-based methods: nearest-neighbors, decision trees; Learning by function approximation: Linear models: (multiclass) support vector machines, ridge regression, Non-linear models: kernel methods, neural networks; Learning by probabilistic modeling- Discriminative methods: (multiclass) logistic regression, generalized linear models, Generative methods: naive Bayes	
	UNSUPERVISED LEARNING	**(06 Hours)**
	Discriminative Models: clustering techniques, PCA (dimensionality reduction); Generative Models- Latent variable models: expectation-maximization for learning latent variable models, Applications: Gaussian mixture models, probabilistic PCA, LDA	
	MISCELLANEOUS TOPICS	**(06 Hours)**

	Dimensionality Measuring Error, Interval Estimation, Hypothesis Testing, Reduction, Feature Selection, Model Selection and Theory of Generalization, In-sample and Out-of-sample Error, bias-variance tradeoffs, overfitting and underfitting, Evaluation measures, Validation	
	ADVANCED TOPICS	**(07 Hours)**
	Ensemble methods: boosting, bagging, random forests; Recommendation systems: ranking methods, collaborative filtering via matrix completion; Reinforcement learning; Statistical learning theory; semi-supervised learning, active learning, Transfer learning; Deep learning: CNN, RNN, LSTM, autoencoders	
	APPLICATIONS	**(05 Hours)**
	Machine Learning in Healthcare, Machine Learning in Agriculture, Machine Learning in Industry, Machine Learning in Education, Machine Learning in Society	
		(Total Contact Time: 45 Hours)

3. Practicals:
1. Exploring machine learning libraries
2. Problems on data data analytics and data visualization
3. Applications of Regression analysis
4. Applications of Decision Tree and SVM
5. Problem related to Logistics Regression
6. Applications of Neural Network
7. Applications of PCA
8. Applications of Clustering Techniques
9. Performance evaluation of ML model
10. Case studies on ML

4. Books Recommended:

1. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer, 2009
3. Tom Mitchell; Machine Learning, First Edition, McGraw Hill, 1997.

REFERENCE BOOKS

1. Kevin P. Murphy; Machine Learning: A Probabilistic Perspective, MIT Press, 2012.
2. Ian Goodfellow, Yoshua Bengio and Aaron Courville; Deep Learning, MIT Press, 2016.

Reference Courses from Other Institutes

https://www.cse.iitk.ac.in/pages/CS771.html
http://www.cse.iitm.ac.in/course_details.php?arg=OA==
https://people.iitism.ac.in/~download/lab%20manuals/mathandcomp/Fundamentals%20of%20Machine%20Learning%20Practical.pdf
https://www.svnit.ac.in/web/department/computer/pdf/mtech/MTech_CSE_Curriculum_2023.pdf

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence
M.Tech. Data Science and Business Intelligence

M.Tech. I (DS & BI) Semester – II BIG DATA ANALYSIS & VISUALIZATION (CORE-4) AI101	Scheme	L	T	P	Credit
		3	0	2	04

1.	Course Outcomes (COs): At the end of the course, students will be able to
CO1	To learn the basics of big data, its characteristics, big data management issues, processing and applications with the help of big data platforms and storage models for big data management..
CO2	To learn the management and analysis of big data using technology like Hadoop, NoSql, MapReduce, PIG & HIVE
CO3	To apply the data mining algorithms on big data for scalability of the real time applications.
CO4	To develop research interest towards advances in data mining by analyzing the available approaches with the help of evaluating parameters.
CO5	To Visualize big data to perform decision making in real world problems

2.	Syllabus	
	INTRODUCTION	**(04 Hours)**
	Definition of Big Data, Source of Big Data, Convergence of Key Trends, Unstructured Data, Industry Examples of Big Data, Web Analytics, Fraud and Risk Associated with Big Data, Credit Risk Management, Big Data in Algorithmic Trading, Healthcare, Medicine, Marketing and Advertising, Big Data Technologies, Introduction to Hadoop and Spark, Open Source Technologies, Cloud, Mobile Business Intelligence, Crowd Sourcing Analytics, Inter and Trans Firewall Analytics.	
	BIG DATA ANALYTICS	**(06 Hours)**
	Big Data Processing: Batch Data Processing and Stream Data Processing, Computing Environments for Big Data Analytics, Implementation of Batch and Real Time Event Processing: Integration of Disparate Data Stores/Data Lake, Mapping Data to the Programming Framework, Connecting and Extracting Data from Storage, Transforming Data for Processing, Querying.	
	DISTRIBUTED FILE SYSTEM HADOOP	**(08 Hours)**
	Introduction, HDFS Daemons, Different Methods to HDFS Access, Hadoop, Features, Google File System Features, Phases involved in Map Reduce, Architecture, Execution of MapReduce Jobs, Monitoring the progress of job flows, Building Blocks of Hadoop MapReduce. Data format, Analyzing data with Hadoop, Scaling Out, Hadoop Streaming, Hadoop Pipes, Design of	

	Hadoop Distributed File System, MapReduce, HDFS Concepts: Java Interface, Data Flow, Hadoop I/O, Data integrity, Compression, Serialization, Avro, File-based Data Structures, Mahout	
	BIG DATA ANALYSIS WITH HBASE, SPARK, HIVE and PIG	**(08 Hours)**
	HBase, Data Model and Implementations, HBase Clients, HBase Examples, Praxis, Cassandra, Cassandra data Model, Cassandra Examples, Cassandra Clients, Hadoop Integration, Hive, Data Types and File Formats, HiveQL Data Definition, HiveQL Data Manipulation, HiveQL Queries, Applications on Big Data Using Pig and Hive, Data Processing Operators in Pig, Fundamentals of ZooKeeper, K-Means Clustering, Decision Trees, Random Forests, Recommenders, Table in Spark, Higher Level Declarative Programming, Network Structure, Computing Graph Statistics.	
	BIG DATA STORAGE MODELS	**(08 Hours)**
	Introduction, NoSQL Databases, Need, Types, Comparison with RDBMS, Architecture and Features Databases: Distributed Hash-table, Key-Value Storage Model, MongoDB Query Language, Document Storage Model, Graph Models, Lambda Architecture, Data Ingestion, Design and Provision Compute Resources, Storage Streaming Units, Configuration of Clusters for Latency and Throughput, Output Visualization	
	INTRODUCTION TO DATA VISUALIZATION	**(05 Hours)**
	Data Visualization, Design, Data and Tasks, Data Types, Dataset Types, Basic Charts and Plots, Use of Statistical Indicators, Multivariate Data Visualization, Principles of Perception, Color, Design, and Evaluation, Graphical Integrity, Data-Ink Ratio, Aspect Ratios & Scales. Formats-Static Graphs, Interactive Graphs, Infographics, Websites, Animated Videos, GIFs. Strategies-Qualitative and Text-Based Data, Color-Coding, Timelines, Calendars, and Diagrams, Filtering, Parallel Coordinates, Aggregation.	
	DATA VISUALISATION FORMAT, CATEGORY AND TOOLS	**(06 Hours)**
	Visual Story Telling, Messaging, Effective Presentations, Design for Information, Visualization and Arts, Visualization Systems, Database Visualization, Redesign Principles and Design Dimensionality, Rapidly Prototype Visualizations, Quantitatively and Qualitatively Evaluation of Visualizations. Visual Story Telling, Messaging, Database Visualization, Rapidly Prototype Visualizations, Quantitatively and Qualitatively Evaluation of Visualizations, Other Data Visualisation Tools, Excel, R, Tableau, Python	
	Practicals will be based on the coverage of the above topics.	**(28 Hours)**
	(Total Contact Time: 45 Hours + 28 Hours = 70 Hours)	

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
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M.Tech. Data Science and Business Intelligence

3.	List of Practical
1	Working with various functions of Hadoop MapReduce.
2	Develop a MapReduce program to calculate the frequency of a given word in agiven file.
3	Working with pySpark and RDDs.
4	Develop a Java application to find the maximum temperature using Spark
5	Regression and classification in Spark.
6	Data analysis with PCA in Spark.
7	Write queries to sort and aggregate the data in a table using HiveQL.
8	Develop a program to calculate the maximum recorded temperature by yearwise for the weather dataset in Pig Latin
9	Hands-on with MLlib and SparkSQL.
10	Use cases and implementation for Big data management and large scale machine learning algorithms.

4.	Books Recommended
1.	Tom White, "HADOOP: The definitive Guide", O Reilly 2012
2.	Michael Minelli, Michele Chambers, Ambiga Dhiraj, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley.
3.	Alberto Cairo, "The Truthful Art: Data, Charts, and Maps for Communication" 1/E, Berkeley, California: New Riders, 2016, ISBN: 9780321934079

5.	Reference Books
1.	Sandy Ryza, Uri Laserson, Sean Owen, Josh Wills, "Advanced Analytics with Spark", O'Reilly.
2.	Jure Leskovec, Stanford Univ.AnandRajaraman, Milliway Labs, Jeffrey D. Ullman, "Mining of Massive Datasets", Cambridge University Press

Syllabus –Ref. from M.Tech. CSE Curriculum, SVNIT Surat, IIT Kanpur, Mumbai University

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence
M.Tech. Artificial Intelligence and Machine Learning

M. Tech. (AI&ML) DEEP LEARNING AIYYY		L	T	P	Credit
	Scheme	3	0	2	4

1. Course Outcomes (COs): At the end of the course, students will be able to	
CO1	Identify problems that could be solved using Deep learning.
CO2	Understand major components and key concepts of CNN, RNN, GAN, and Transformers.
CO3	Understand recent advancements in GANs.
CO4	Analyze and apply deep learning models for image and text tasks.
CO5	Design applications of Deep learning in Pytorch and Keras.

2.	Syllabus	
	Introduction to Deep learning	**(08 Hours)**
	Supervised learning, Unsupervised learning, Reinforcement learning, Shallow neural network, From fully Connected Layers to Convolutions, Convolutions for images, Padding and Stride, Pooling, Convolution Neural Networks (LeNet) and floating point operations (FLOP), Gradient Descent, Optimization Algorithms in Deep learning.	
	Modern Convolution Neural Networks	**(06 Hours)**
	Deep Convolution Neural Networks (AlexNet), Network using Blocks (VGG), Network in Network (NiN), Multi-Branch Networks (GoogLeNet), BatchNormalization, Layer Normalization, Instance Normalization, Group Normalization, Residual Networks (ResNet), Densely Connected Network (DenseNet).	
	Modern Recurrent Neural Networks	**(08 Hours)**
	Working with sequences, Converting Raw Text into Sequence Data, Basic of Language models, Recurrent Neural Networks, Long Short-Term Memory (LSTM), Gated Recurrent Units (GRU), Deep Recurrent Neural Networks, Bidirectional Recurrent Neural Networks.	
	Introduction to Generative Modeling	**(08 Hours)**
	Generative modeling, RBM, DBN, Auto-encoder, Variational Auto encoders (VAE), Generative Adversarial Networks (GANs), GAN Training and loss function, GAN Challenges, Mode Collapse, Variants of GANs (DCGAN, cGAN, WGAP,WGAN-GP)	
	Applications of GANs and Advanced Topics	**(06 Hours)**
	Image-to-Image Translation (pix2pix), Neural Style Transfer (Style GAN), Face Manipulation, Super-resolution, Inpainting, Image Segmentation, future of Generative Modeling.	

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	Introduction to Transformers and its Applications	**(09 Hours)**
	Attention Mechanisms, Natural Language, Transformer Language Models, Sequence-to-Sequence transformers, Vision Transformers. Text classification, Question Answering, Translation, Text Generation, future of Transformers	
	(Total Contact Time: 45 Hours +15 Hours = 60 Hours)	

3. Practicals:
1. Basic Programming on deep learning frameworks Pytorch/Keras deep learning frameworks
2. Image classification using difference CNN architecture in Pytorch/Keras.
3. Transfer Learning of pretrained models on MNIST dataset.
4. Time-Series Forecasting with the LSTM Model in Pytorch/Keras.
5. Deep learning Techniques for image segmentation in Pytorch/Keras.
6. Autoencoders using MNIST Handwritten digits in Pytorch/Keras.
7. GAN for generating synthetic image on MNIST Handwritten digits dataset.
8. DCGAN for generating synthetic image on CIFAR dataset.
9. Test classification using Transformer
10. Minor Project on classification and synthetic image generation.

4. Books Recommended:

1. Dive into Deep Learning: Book by Aston Zhang, Zack C. Lipton, Mu Li, Alex J. Smola.
2. Deep Learning. Book by Ian Goodfellow and Yoshua Bengio and Aaron Courville, The MIT
3. Deep Learning Foundations and Concepts, Book by, Christopher M. Bishop, Hugh Bishop

5. REFERENCE BOOKS

4. Josh Patterson and Adam Gibson, "Deep learning: A practitioner's approach", O'Reilly Media, First Edition, 2017.
5. Seth Weidman,Deep Learning from Scratch: Building with Python from First Principles, O'Reilly

Additional Resource

http://introtodeeplearning.com: Course lectures for MIT Introduction to Deep Learning.

https://www.youtube.com/playlist?list=PLtBw6njQRU-rwp5 7C0oIVt26ZgjG9NI

Elective list: M.Tech Data Science & Business Intelligence

Code	Subject Name	
Core Elective 1 and 2		
1	Learning Analytics and Educational Data Mining	
2	Time Series for Business Analytics	
3	Knowledge Modeling and Semantic Web Technologies	
4	Pattern Recognition	
5	Edge Computing	
6	Computer Graphics	
7	Information Retrieval	
8	AI for Finance & Investment	
9	Block chain Technology	
10	Advanced Statistical Techniques	
11	Predictive Modeling and Analytics	
12	Ethics and Professional Life Intellectual Property	
13	Federated Learning	
14	Stream Processing and Analytics	
15	Ethics and Governance in Data Science	
Core Elective 3 and 4		
1	Data Acquisition System	
2	Advanced Database Management System	
3	Decision Analysis and Engineering	
4	Bitcoin and Crypto-currency	
5	Unmanned Aerial Vehicles Forensics	
6	Game Theory	
7	Quantum Machine Learning	
8	Advanced Topics on Cloud Computing for AI and ML	
9	Advanced Topics in Computational Intelligence	
10	Data Science for Software Engineering	
11	Security and Privacy in Resource Constrained Environments	
12	Speech and Audio Processing	
13	Formal Specification and Verification	
14	Foundation of Business Analytics	
15	Social Media Analytics	
Institute Elective		
1	Research Methodology	
2	Ethical AI / Ethics, Patents, Copyrights, and IPR	
3	Courses offered through NPTEL/SWAYAM	

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
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M.Tech. Artificial Intelligence & Machine Learning / Data Science & Business Intelligence

INTAKE, INFRASTRUCTURE, MANPOWER & FINANCIAL MANAGEMENT

INTAKE

S.No	Course	Number of Intake		Total Intake
		Through CCMT	Through Institute Sponsored	
1	M.Tech in AI & ML	30	05	35
2	M.Tech in Data Science & Business Intelligence	30	05	35
			Total Intake	**70**

INFRASTRUCTURE

1- Classroom requirement:
Existing labs and classrooms in the department will be shared. Additionally, one more classroom is required.

MANPOWER

1- Academic year wise Faculty and Infrastructure requirement

Sr. No.	Program Name	Student Intake	Academic year	Faculty required	Infrastructure requirement
1	M.Tech. Artificial Intelligence & Machine Learning	35	2025-26	2 (0:0:2)	Existing labs and classrooms in the department will be shared. Additionally, one more classroom with 40 benches is required.
			2026-27	4 (0:2:2) (SFR 15:1)	
			Total faculty	04	
2	M.Tech. Data Science & Business Intelligence	35	2025-26	2 (0:0:2)	Existing labs and classrooms in the department will be shared. Additionally
			2026-27	4 (0:2:2) (SFR 15:1)	Existing labs and classrooms in the department will be shared.
			Total faculty	04	

2- Non Teaching Staff Requirements

- Clerk: 1

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- Lab Technician: 1
- Peon: 1

FINANCIAL MANAGEMENT

1- Fees Structure

The fee structure will be followed as per institute norms.

Sr. No.	Program Name	Academic Year	Number of Students	Tuition Fee Collection	Faculty Salary	Scholarship from MoE
1	M.Tech. Artificial Intelligence with Specialization in Artificial Intelligence And Machine Learning	2024-25	35	**24,50,000** (= 35,000 x 35 x 2)	**32,40,000** (1,35,000 x 2 x 12)	**45,00,000** (12,500 x 30 x 12)
		2025-26	70	**49,00,000**	**94,80,000** [(2,75,000 + 2,60,000 + 2,70,000) x 12]	**90,00,000**
2	M.Tech. Artificial Intelligence with Specialization in Data Science & Business Intelligence	2024-25	35	**24,50,000**	**32,40,000**	**45,00,000**
		2025-26	70	**49,00,000**	**94,80,000**	**90,00,000**

2- Non Teaching additional Cost

Designation	Scale	Number	Approx Amount per month	Approx Amount per year
Clerk	**21700**	**01**	Rs 42,000	Rs. 42000 X 12 = Rs.5,04, 000
Clerk	**21700**	**01**	Rs 42,000	Rs. 42000 X 12 = Rs.5,04, 000
Peon	**18000**	**01**	Rs. 32,000	Rs. 32000 X 12 = Rs. 3, 84, 000
			Total	**Rs 13, 92, 000**

Annexure 67.4
of 67th meeting of the IAAC

Department of Artificial Intelligence
M.Tech in Artificial Intelligence & Machine Learning

Teaching Scheme

Sr. No.	Subject	Code	Scheme L-T-P	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
				Th	T	P		
				Marks	Marks	Marks		
	First Semester							
1	Core subject – 1 Probability and Statistics		3-1-0	100	25	0	4	75
2	Core Subject – 2 Linear Algebra & Optimization		3-1-0	100	25	0	4	75
3	Core subject – 3 Machine Learning		3-0-2	100	0	50	4	100
4	Elective -1		3-0-2	100	-	50	4	100
5	Elective - 2		3-1-0	100	25	-	4	100
				Total			**20**	**450**
6	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)		0-0-10				5	200 (20 x 10)
	Second Semester							
1	Core subject – 4 Swarm Intelligence & Nature-Inspired algorithm		3-0-2	100	-	50	4	100
2	Core Subject – 5 Deep Learning		3-0-2	100	-	50	4	100
3	Elective -3		3-1-0	100	25	-	4	75
4	Elective -4		3-1-0	100	25	-	4	75
5	Institute Elective*		3-0-0	100	-	-	3	55
6	Mini Project		0-0-4	-	-	100	2	70
						Total	**21**	**475**
7	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)		0-0-10				5	200 (20 x 10)

Sr. No.	Subject	Code	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
			Th. Marks	T Marks	P Marks		
	Third Semester						
1	MOOC course – I*		-	-	-	3/4[φ]	70/80
2	MOOC course – II*		-	-	-	3/4[φ]	70/80
3	Dissertation Preliminaries		-	-	350[$]	14	560
			Total			**20-22**	**700-720**
	Fourth Semester						
1	Dissertation		-	-	600[$]	20	800

[$] **Internal**: 40% and **External**: 60%

*Swayam/NPTEL

φAs per 66th IAAC, Dated 20th March, 2024, Resolution No. 66.34 and 61st Senate resolution No. 4, 25th April, 2024.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence
M.Tech. Artificial Intelligence and Machine Learning

M. Tech. (AI&ML) Probability and Statistics AIYYY		L	T	P	Credit
	Scheme	3	0	2	04

1. Course Outcomes (COs): At the end of the course, students will be able to	
CO1	To provide mathematical background and sufficient experience so that student can read, write and understand sentences in the language of probability theory.
CO2	To introduce students to the basic methodology of "probabilistic thinking" and apply it to problems.
CO3	To understand basic concepts of Probability theory and Random Variables, how to deal with multiple Random Variables.
CO4	To understand the difference between time averages statistical averages.
CO5	To teach students how to apply sums and integrals to compute probabilities, and expectations.

2.	Syllabus	
	Basic of Probability	(6 Hours)
	Introduction, Axioms of Probability & its properties, Joint Probability, Marginal Probability, Conditional Probability, Bayes Theorem, Independence of Events, Total Probability theorem, Central limit theorem, Chain Rule of Conditional Probabilities	
	Random Variables and Probability Distributions	(8 Hours)
	Distribution Functions of Discrete Variables: Bernoulli Distribution Binomial Distribution Geometric Distribution, Poisson distribution, Distribution Functions of Continuous Variables: Uniform, Exponential, Normal (Gaussian), Gamma Distribution. Mean, Variance of Random Variables & higher order moments, Expectation of function of Random variables, Characteristic, Functions, Chebychev Inequality.	
	Multivariate Random Variables	(8 Hours)
	Bivariate Discrete Random Variables. Bivariate Continuous Random Variables. Conditional Distributions. Independence of Random Variables, Multivariate Random variables, Joint, Marginal, and conditional PMF, PDF, and CDF.	
	Product Moments of Bivariate Random Variables	(4 Hours)
	Covariance of Bivariate Random Variables, Independence of Random Variables, Variance of the Linear, Combination of Random Variables, Correlation and Independence.	
	Sampling Theory	(8 Hours)

	Population and Sample. Statistical Inference Sampling With and Without Replacement Random Samples. Random Numbers Population Parameters. Sample Statistics, Sampling Distributions, Sample Mean, Sampling Distribution of Means, Sampling Distribution of Proportions, Sampling Distribution of Differences and Sums, Sample Variance, Sampling Distribution of Variances, Case Where Population Variance Is Unknown Sampling Distribution of Ratios of Variances Other Statistics Frequency Distributions Relative Frequency Distributions Computation of Mean, Variance, and Moments for Grouped Data	
	Estimation Theory	**(5 Hours)**
	Unbiased Estimates and Efficient Estimates Point Estimates and Interval Estimates. Reliability Confidence Interval Estimates of Population Parameters Confidence Intervals for Means Confidence Intervals for Proportions Confidence Intervals for Differences and Sums Confidence Intervals for the Variance of a Normal Distribution Confidence Intervals for Variance Ratios Maximum Likelihood Estimates	
	Tests of Hypotheses and Significance	**(5 Hours)**
	Statistical Decisions Statistical Hypotheses. Null Hypotheses Tests of Hypotheses and Significance Type I and Type II Errors Level of Significance Tests Involving the Normal Distribution One-Tailed and Two-Tailed Tests PValue Special Tests of Significance for Large Samples Special Tests of Significance for Small Samples Relationship Between Estimation Theory and Hypothesis Testing Operating Characteristic Curves. Power of a Test Quality Control Charts Fitting Theoretical Distributions to Sample Frequency Distributions The Chi-Square Test for Goodness of Fit.	
	(Total Contact Time: 45 Hours + 15 Hours =60 Hours)	

4 Tutorial:	
	1. Analytical and real world problem on basic probability
	2. Numerical problems on Bayes theorem
	3. Proof on various probability distribution function
	4. Problem on bivariate probability distribution function
	5. Problem on Multivariate probability distribution function
	6. Derivation on Moment generating function
	7. Real time numerical example on Estimation theory likes weather forecasting, radar transit time etc.
	8. Real time numerical on hypothesis test e.g. Telecom service, online purchase system, election etc
	9. Numerical problem on significance Type 1 and Type 2 error impact on decision making
	10. Numerical problem based on chi-square goodness of fit test on categorical dataset.

Books Recommended:

1. Murray R. Spiegel, John J. Schiller, and R. Alu Srinivasan, Probability and Statistics, Schaum's Outline Series, Mc Graw Hill
2. A. Papoulis & S. U. Pillai, "Probability, Random Variable Variables & Stochastic Processes", 4th Ed,

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McGraw Hill Publication, 2016.

3. S. M. Ross, Introduction to Probability Models", Academic Press, 12th Edition, 2019.

REFERENCE BOOKS

4. Gersting J.L., "Mathematical Structure for Computer Science", W.H. Freeman and Co., 3rd Edition, 1993
5. Probability and Statistics for Engineers and Scientists, Ronald E. Walpole, Raymond H. Myers

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Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence
M.Tech. Artificial Intelligence and Machine Learning

B. Tech. II (AI) Semester – III Linear algebra & optimization AIYYY		L	T	P	Credit
	Scheme	3	0	2	04

1. Course Outcomes (COs): At the end of the course, students will be able to	
CO1	Understand the basic theory of vector spaces: linear independence, spanning, bases, dimension, subspaces
CO2	Understand the basic theory of linear transformations: matrix representation, diagonalisation, orthogonal diagonalisation
CO3	Carry out the basic techniques of the following: row-reduction and LU decomposition to solve systems of linear equations; calculating determinants; finding eigenvalues and eigenvectors and diagonalising matrices; orthogonally diagonalising matrices
CO4	Formulation of single variable and multi variable optimization algorithms to solve engineering problems
CO5	Compute constraints optimization for optimal search methods

.2.	Syllabus	
	Vector Spaces	(6 Hours)
	Vector Space, Subspaces, Linear Span and Linear Dependence, Linear Independence, Basic and Dimension, Linear Functions, Norm of Vector, Affine Functions, Function Composition, System of Linear Equations, Inevitability of Matrices.	
	Least squares and Eigenvalues	(8 Hours)
	Orthogonal Vectors and Subspaces, Projection on Subspace, Triangular Systems, LU Decomposition, QR Decomposition, Matric Norm, Sensitivity Analysis, Condition Number of a Matrix, Least Squares, Least Square data fitting, Classification using Least Squares. Eigenvalues and Eigenvector, Spectral Decomposition Theorem, Positive Definite Matrices	
	Dimensionality reduction	(8 Hours)
	Sensitivity Analysis: Singular Value Decomposition, Properties of SVD, Low Rank Approximations, Principal Component Analysis, SVD and Pseudo-Inverse, SVD and Least Square problem, Power Method	
	Linear Programming problems	(8 Hours)
	Formation of LPP, Feasible solution, Basic feasible solutions, Types of solutions, Graphical method, The Simplex Method, Big M Method, Revised simplex method, Two phase method, Duality and Dual simplex method. Transportation problems, Assignment problems, Travelling Salesman Problem, Shortest Path	

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	Algorithms and Network flow problems	
	Unconstrained Problems	**(7 Hours)**
	Convex Sets and Convex Functions, Basic properties of solutions and algorithms, Global convergence. Fibonacci search method, Golden Section Search, Line Search Methods, Steepest Descent and Newton Methods, Modified Newton methods, Globally convergent Newton Method, Nonlinear Least Squares Problem and Algorithms, Conjugate Direction Methods, Trust-Region Methods.	
	Quadratic Programming and Direct Methods	**(8 Hours)**
	Quadratic Programming : Gradient Projection methods and sequential quadratic programming. Dual Methods : Augmented Lagrangians and cutting-plane methods, Penalty and Barrier Methods, Interior Point Methods	
	(Total Contact Time: 45Hours +15 Hours =60 Hours)	

4.	**Tutorial:**
1.	Numerical problem on Vectors operation and Matrices operation.
2.	Linear Transformation problem on generate complex shape from basic shapes.
3.	Matrix factorization problem on recommender system
4.	Positive definitive matrices numerical problem in context to machine learning and finance.
5.	Eigenvalues and Eigenvector based numerical problem for dimensional reduction
6.	Explain how the Singular Value Decomposition used in image compression techniques
7.	Real world numerical problem solution using Transportation
8.	Real world numerical problem solution Travelling Salesman Problem
9.	Primal-Dual and Dual Algorithms for the Assignment and Transportation Problems
10.	Multivariate optimization based case study in data science

5. Books Recommended:

1. David C. Lay, "Linear Algebra and its Applications," 3rd edition, Pearson Education (Asia) Pte. Ltd,2005.

2 Kenneth Hoffman and Ray Kunze, "Linear Algebra," 2nd edition, Pearson Education (Asia) Pte. Ltd/2004.

3. P. E. Gill, W. Murray, and M. H. Wright, Practical Optimization, Academic Press.

4. KalyanmoyDeb,"OptimizationforEngineeringDesign",11th Edition, PHILearning(P), Limited, 2010.

REFERENCE BOOKS

1. Bernard Kolman and David R. Hill, "Introductory Linear Algebra with Applications", Pearson Education

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(Asia) Pte. Ltd, 7th edition, 2003.

2. Gilbert Strang, "Linear Algebra and its Applications", 3rd edition, Thomson Learning Asia, 2003.

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Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence

M. Tech. I (AI) Semester –I MACHINE LEARNING AI201		L	T	P	Credit
	Scheme	3	0	2	04

1. Course Outcomes (COs): At the end of the course, students will be able to	
CO1	To understand the basic concepts, state-of-the art techniques of machine learning, statistical analysis and discriminant functions
CO2	To apply different concepts for the machine learning problems
CO3	To apply and analyze different supervised and unsupervised learning approaches as per the suitability of the problem
CO4	To understand and evaluate machine learning methods to use them
CO5	To design solution of problem using different machine learning approaches

2.	Syllabus	
	MATHEMATICS FOR MACHINE LEARNING	(06 Hours)
	Multivariate calculus: gradient, Hessian, Jacobian, chain rule; Linear algebra: determinants, eigenvalues/vectors, SVD; Probability theory: conditional probability, marginal probability, Bayes rule	
	INTRODUCTION	(05 Hours)
	Introduction to machine learning- Introduction to Machine Learning, Why Machine Learning?, Types, Applications of M/L, Classification and Regression, Data preprocessing and data visualization	
	SUPERVISED LEARNING	(10 Hours)
	Local/proximity-based methods: nearest-neighbors, decision trees; Learning by function approximation: Linear models: (multiclass) support vector machines, ridge regression, Non-linear models: kernel methods, neural networks; Learning by probabilistic modeling- Discriminative methods: (multiclass) logistic regression, generalized linear models, Generative methods: naive Bayes	
	UNSUPERVISED LEARNING	(06 Hours)
	Discriminative Models: clustering techniques, PCA (dimensionality reduction); Generative Models- Latent variable models: expectation-maximization for learning latent variable models, Applications: Gaussian mixture models, probabilistic PCA, LDA	
	MISCELLANEOUS TOPICS	(06 Hours)

	Dimensionality Measuring Error, Interval Estimation, Hypothesis Testing, Reduction, Feature Selection, Model Selection and Theory of Generalization, In-sample and Out-of-sample Error, bias-variance tradeoffs, overfitting and underfitting, Evaluation measures, Validation	
	ADVANCED TOPICS	**(07 Hours)**
	Ensemble methods: boosting, bagging, random forests; Recommendation systems: ranking methods, collaborative filtering via matrix completion; Reinforcement learning; Statistical learning theory; semi-supervised learning, active learning, Transfer learning; Deep learning: CNN, RNN, LSTM, autoencoders	
	APPLICATIONS	**(05 Hours)**
	Machine Learning in Healthcare, Machine Learning in Agriculture, Machine Learning in Industry, Machine Learning in Education, Machine Learning in Society	
		(Total Contact Time: 45 Hours)

3. Practicals:
1. Exploring machine learning libraries
2. Problems on data data analytics and data visualization
3. Applications of Regression analysis
4. Applications of Decision Tree and SVM
5. Problem related to Logistics Regression
6. Applications of Neural Network
7. Applications of PCA
8. Applications of Clustering Techniques
9. Performance evaluation of ML model
10. Case studies on ML

4. Books Recommended:

1. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer, 2009
3. Tom Mitchell; Machine Learning, First Edition, McGraw Hill, 1997.

REFERENCE BOOKS

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1. Kevin P. Murphy; Machine Learning: A Probabilistic Perspective, MIT Press, 2012.
2. Ian Goodfellow, Yoshua Bengio and Aaron Courville; Deep Learning, MIT Press, 2016.

Reference Courses from Other Institutes

https://www.cse.iitk.ac.in/pages/CS771.html
http://www.cse.iitm.ac.in/course_details.php?arg=OA==
https://people.iitism.ac.in/~download/lab%20manuals/mathandcomp/Fundamentals%20of%20Machine%20Learning%20Practical.pdf
https://www.svnit.ac.in/web/department/computer/pdf/mtech/MTech_CSE_Curriculum_2023.pdf

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Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence
M.Tech. Artificial Intelligence & Machine Learning

M.Tech. I (AI) Semester – II SWARM INTELLIGENCE & NATURE INSPIRED ALGORITHM (CORE-4) AIXXXX	Scheme	L	T	P	Credit
		3	0	2	04

1.	Course Outcomes (COs): At the end of the course, students will be able to
CO1	Understand and explain the principles of Swarm Intelligence and its key algorithms, including Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO), and others.
CO2	Implement and evaluate various nature-inspired optimization algorithms, such as Cuckoo Search Algorithm, Artificial Bee Colony, and Genetic Algorithms, to solve complex optimization problems.
CO3	Analyze the performance of different nature-inspired algorithms in solving real-world problems and compare their effectiveness based on criteria such as convergence speed, accuracy, and computational efficiency.
CO4	Apply Swarm Intelligence techniques to design and develop solutions for problems involving collective behavior and adaptive systems, such as swarm robotics and food foraging behavior.
CO5	Visualize and interpret the results of nature-inspired optimization algorithms, including the evolution of solutions, algorithmic behavior, and the impact of various parameters on performance.

2.	Syllabus	
	INTRODUCTION	**(04 Hours)**
	From Nature to Nature Computing , Philosophy , Introduction to Optimization, Introduction to Evolutionary Computation , Algorithmic Challenges and Responses, Different optimization techniques, Optimization Problems	
	COMPUTING INSPIRED BY NATURE	**(08 Hours)**
	Evolutionary Computing, Hill Climbing and Simulated Annealing, Darwin's Dangerous Idea, Genetics Principles, Standard Evolutionary Algorithm -Genetic Algorithms , Reproduction-Crossover, Mutation, Evolutionary Programming, Genetic Programming	
	SWARM INTELLIGENCE FUNDAMENTALS	**(08 Hours)**
	Introduction to Swarm Intelligence: Overview of swarm intelligence, basic concepts and principles. Ant Colonies: Ant colonies: Introduction, behavior, and foraging, Ant Colony Optimization (ACO): Algorithms and applications. Swarm Robotics and Social Adaptation: Swarm robotics: Concepts and applications, foraging behavior and social adaptation of knowledge.	

	ADVANCED SWARM INTELLIGENCE	**(08 Hours)**
	Advanced Ant Colony Optimization: SACO and scope of ACO algorithms, Ant Colony Algorithm (ACA).Additional Swarm Intelligence Techniques: Particle Swarm Optimization (PSO): Principles and applications, Glowworm Swarm Optimization: Principles and use cases.	
	CORE NATURE-INSPIRED TECHNIQUES	**(08 Hours)**
	Genetic Algorithms (GA): Basics, reproduction, crossover, and mutation. Bat Algorithm and Cuckoo Search Algorithm: Bat Algorithm: Mechanisms and applications, Cuckoo Search Algorithm: Techniques and use cases. Artificial Bee Colony (ABC): Concepts and applications.	
	ADVANCED NATURE-INSPIRED TECHNIQUES	**(09 Hours)**
	Shuffled Frog Leap Algorithm: Description and implementation, Brain Storm Swarm Optimization Algorithm: Approach and applications, Intelligent Water Drop Algorithm: Mechanisms and uses, Egyptian Vulture Algorithm: Overview and applications. Biogeography-Based Optimization (BBO) and Other Techniques: Biogeography-Based Optimization (BBO): Concepts and implementations, Invasive Weed Optimization: Techniques and applications, Bacteria Foraging Optimization Algorithm: Description and applications, Flower Pollination Algorithm: Mechanisms and applications.	
	(Total Contact Time: 45 Hours + 30 Hours= 75 Hours)	

3.	**List of Practical**
1	Implement a basic Particle Swarm Optimization (PSO) algorithm to solve a simple optimization problem (e.g., minimizing a function). Visualize the movement of particles and their convergence towards the optimal solution.
2	Implement an evolutionary algorithm to optimize a function, visualizing population evolution.
3	Simulate a genetic algorithm using selection, crossover, and mutation on binary strings.
4	Implement evolutionary programming to optimize a multi-modal function and compare with genetic algorithms.

5	Develop a genetic algorithm to optimize the job scheduling problem, including selection, crossover, and mutation operations; visualize solution evolution and evaluate algorithm performance.
6	Simulate the movement of a group of ants in a simple grid environment, where ants randomly explore their surroundings. Observe and document their paths.
7	Perform a comparative study of ACO, Genetic Algorithm (GA), and Particle Swarm Optimization (PSO) on a benchmark optimization problem. Analyze the convergence rates, solution quality, and computational efficiency of each algorithm.
8	Develop a Brain Storm Swarm Optimization Algorithm to solve a complex function optimization problem.
9	Implement the Cuckoo Search Algorithm to optimize the Sphere function. Visualize nest positions and their evolution over iterations.
10	Implement the Bat Algorithm to optimize a benchmark function. Visualize the position and velocity updates of bats over iterations. Analyze and discuss the performance of the algorithm.

4.	**Books Recommended**
1.	Floreano D. and Mattiussi C., "Bio-Inspired Artificial Intelligence: Theories, Methods, and Technologies", MIT Press, Cambridge, MA, 2008.
2.	Albert Y.Zomaya, "Handbook of Nature-Inspired and Innovative Computing", Springer, 2006.
3.	Marco Dorrigo, Thomas Stutzle," Ant Colony Optimization", PHI.200

5.	**Reference Books**
1.	Anupam Shukla, Ritu Tiwari, " Discrete Problems in Nature Inspired Algorithms", CRC Press, 2017

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Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence
M.Tech. Artificial Intelligence and Machine Learning

M. Tech. (AI&ML) DEEP LEARNING AIYYY		L	T	P	Credit
	Scheme	3	0	2	4

1. **Course Outcomes (COs):** **At the end of the course, students will be able to**	
CO1	Identify problems that could be solved using Deep learning.
CO2	Understand major components and key concepts of CNN, RNN, GAN, and Transformers.
CO3	Understand recent advancements in GANs.
CO4	Analyze and apply deep learning models for image and text tasks.
CO5	Design applications of Deep learning in Pytorch and Keras.

2.	**Syllabus**	
	Introduction to Deep learning	**(08 Hours)**
	Supervised learning, Unsupervised learning, Reinforcement learning, Shallow neural network, From fully Connected Layers to Convolutions, Convolutions for images, Padding and Stride, Pooling, Convolution Neural Networks (LeNet) and floating point operations (FLOP), Gradient Descent, Optimization Algorithms in Deep learning.	
	Modern Convolution Neural Networks	**(06 Hours)**
	Deep Convolution Neural Networks (AlexNet), Network using Blocks (VGG), Network in Network (NiN), Multi-Branch Networks (GoogLeNet), BatchNormalization, Layer Normalization, Instance Normalization, Group Normalization, Residual Networks (ResNet), Densely Connected Network (DenseNet).	
	Modern Recurrent Neural Networks	**(08 Hours)**
	Working with sequences, Converting Raw Text into Sequence Data, Basic of Language models, Recurrent Neural Networks, Long Short-Term Memory (LSTM), Gated Recurrent Units (GRU), Deep Recurrent Neural Networks, Bidirectional Recurrent Neural Networks.	
	Introduction to Generative Modeling	**(08 Hours)**
	Generative modeling, RBM, DBN, Auto-encoder, Variational Auto encoders (VAE), Generative Adversarial Networks (GANs), GAN Training and loss function, GAN Challenges, Mode Collapse, Variants of GANs (DCGAN, cGAN, WGAP,WGAN-GP)	
	Applications of GANs and Advanced Topics	**(06 Hours)**
	Image-to-Image Translation (pix2pix), Neural Style Transfer (Style GAN), Face Manipulation, Super-resolution, Inpainting, Image Segmentation, future of Generative Modeling.	

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M.Tech. Artificial Intelligence and Machine Learning

	Introduction to Transformers and its Applications	**(09 Hours)**
	Attention Mechanisms, Natural Language, Transformer Language Models, Sequence-to-Sequence transformers, Vision Transformers. Text classification, Question Answering, Translation, Text Generation, future of Transformers	
	(Total Contact Time: 45 Hours +15 Hours = 60 Hours)	

3. Practicals:
1. Basic Programming on deep learning frameworks Pytorch/Keras deep learning frameworks
2. Image classification using difference CNN architecture in Pytorch/Keras.
3. Transfer Learning of pretrained models on MNIST dataset.
4. Time-Series Forecasting with the LSTM Model in Pytorch/Keras.
5. Deep learning Techniques for image segmentation in Pytorch/Keras.
6. Autoencoders using MNIST Handwritten digits in Pytorch/Keras.
7. GAN for generating synthetic image on MNIST Handwritten digits dataset.
8. DCGAN for generating synthetic image on CIFAR dataset.
9. Test classification using Transformer
10. Minor Project on classification and synthetic image generation.

4. Books Recommended:

1. Dive into Deep Learning: Book by Aston Zhang, Zack C. Lipton, Mu Li, Alex J. Smola.
2. Deep Learning. Book by Ian Goodfellow and Yoshua Bengio and Aaron Courville, The MIT
3. Deep Learning Foundations and Concepts, Book by, Christopher M. Bishop, Hugh Bishop

5. REFERENCE BOOKS

4. Josh Patterson and Adam Gibson, "Deep learning: A practitioner's approach", O'Reilly Media, First Edition, 2017.
5. Seth Weidman,Deep Learning from Scratch: Building with Python from First Principles, O'Reilly

Additional Resource

http://introtodeeplearning.com: Course lectures for MIT Introduction to Deep Learning.

https://www.youtube.com/playlist?list=PLtBw6njQRU-rwp5 7C0oIVt26ZgjG9NI

Pranay Atmaj

Elective List: M.Tech Artificial Intelligence & Machine Learning

Code	Subject Name	
Core Elective 1 and 2		
1	Probabilistic Graphical Models	
2	Computational Linguistics & Natural Language Processing	
3	Reinforcement Learning	
4	Computer Vision and Image Processing	
5	Multi-Agent systems	
6	Parallel & Concurrent Programming	
7	AI for Robotics	
8	Computer graphics	
9	Information Theory & Coding	
10	Surveillance Video Analytics	
11	Generative AI	
12	Quantum ML	
13	Satellite Data Analysis	
14	Cognitive Systems	
15	AI for Biomedical Image Processing	
Core Elective 3 and 4		
1	Scalable Data Systems	
2	Advanced Distributed Systems	
3	Social Computing and Networks	
4	Information Retrieval	
5	AI for Sustainability	
6	AI for cyber Physical System	
7	LLM (Large Language Model)	
8	Digital Forensics	
9	Bioinformatics	
10	Block chain Technology	
11	Advanced Data Mining	
12	Multimedia System & Applications	
13	Advanced Topics in Machine Learning	
14	Drone and Automation Systems	
15	Advanced Topics for Robotics Process Automation	
Institute Elective		
1	Research Methodology	
2	Ethical AI / Ethics, Patents, Copyrights, and IPR	
3	Courses offered through NPTEL/SWAYAM	

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ANNEXURE 2

B.Tech. IV (Chemical Engineering) CATALYST SCIENCE AND TECHNOLOGY (CH4XX) Elective	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):** **At the end of the course, the students will be able to**
CO1	Describe concepts and significance related to heterogeneous and homogeneous catalysts
CO2	Explain steps and methods in catalyst preparation
CO3	Describe and apply selected catalyst characterization methods (identify anayltical tools for specific catalytic applications)
CO4	Explain why and how catalysts deactivate and how catalyst deactivation can be postponed or prevented
CO5	Outline dis-/advantages of supported and full-catalysts with respect to their application
CO6	Explain industrial catalytic processes

2.	**Syllabus**	
	INTRODUCTION TO CATALYSIS	**(02 Hours)**
	Significance of catalysis, Heterogeneous Catalysis: Examples, Case Histories and Current Trends.	
	SOLID CATALYSIS	**(06 Hours)**
	Types of catalysts, Preparation methods of Solid Heterogeneous Catalysts, Catalyst supports, Activation.	
	CATALYSTS CHARACTERIZATION METHODS	**(08 Hours)**
	Adsorption methods, Physicochemical Properties, Spectroscopic Methods.	
	CATALYST PERFORMANCE	**(04 Hours)**
	Testing of catalysts, activity and selectivity studies.	
	EFFECT OF TRANSPORT PROCESSES	**(04 Hours)**
	External transport processes, internal transport processes for reaction and diifusion in porous catalysts.	
	MECHANISM OF CATALYTIC REACTIONS	**(04 Hours)**
	Rates of adsorption, desorption, surface reactions, rate determining steps.	
	KINETIC MODELLING AND PARAMETER ESTIMATIONS.	**(04 Hours)**

	Kinetic study and parametric evaluation.	
	CATALYSTS DEACTIVATION	**(02 Hours)**
	Promoters, inhibitors, catalyst deactivations, kinetics of catalyst deactivations.	
	INDUSTRIAL CATALYSIS APPLICATION	**(06 Hours)**
	Green Chemistry, Biomass to biofuels and chemicals, CO_2 utilization etc.	
	NEW DEVELOPMENT IN SOLID CATALYSIS	**(02 Hours)**
	Monolith catalysts, Nanocatalysts, etc.	
	INTRODUCTION TO HOMOGENEOUS CATALYSIS	**(03 Hours)**
		(Total Contact Time: 45 Hours)

3.	Books Recommended
1	J. M. Thomas and W. J. Thomas, "Principles and Practice of Heterogeneous Catalysis", Wiley- VCH. ISBN: 978-3-527-31458-4 February 2015
2	C. H. Bartholomew and R. J. Farrauto "Fundamentals of Industrial catalytic Processes", Wiley-VCH. ISBN: 978-0-471-73007-1 August 2010
3	Julian Ross: Heterogeneous Catalysis - Fundamentals and Applications, © Elsevier 2012.
4	S. Lowell, Joan E. Shields, Martin A. Thomas, Matthias Thommes. Characterization of Porous Solids and Powders: Surface Area, Pore Size and Density. 2004, Springer Science, New York
5	Fogler H.S., "Elements of Chemical Reaction Engineering", 4th Edition, Prentice Hall, NJ, 2006
6	Articles from Peer Reviewed Journals

M. Tech. I (Chemical Engineering) ADVANCED MATERIALS AND ADVANCED PROCESS (CHCH1YY) Elective	Scheme	L	T	P	Credit
		3	0	0	03

1. **Course Outcomes (COs):** **At the end of the course, students will be able to**	
CO1	Understand the importance of advanced materials, and types of synthesis methods and their applications, Learn advantages, chemical synthesis methods of advanced materials and aspects involved in chemical methods of advanced materials synthesis
CO2	Learn features involved in advanced catalyst preparation methods and applications
CO3	Learn aspects involved in advanced materials synthesis and thin film preparation methods for energy sectors and aspects and controlling operating parameter involved
CO4	**Analyse** for best sequence with Heuristics and **Apply** practical knowledge for process simulation. **Design** Multicomponent Distillation, shortcut method of design
CO5	**Evaluate** Column Diameter and **Apply** Separation process selection thumb rules, and equipment selection thumb rules
CO6	**Design** of heat integration with pinch technology and heat exchanger network design.

2.	**Syllabus**	
	OVERVIEW	**(02 Hours)**
	Prominence of advanced materials, types of synthesis methods and their applications, Superior Properties of advanced materials.	
	SYNTHESIS AND CHARACTRIZATION OF ADVANCED MATERIALS	**(08 Hours)**
	Colloidal synthesis of various advanced structures, channels of zeolites, Phase behavior of synthesis systems such as colloidal systems. Characterization and measurement of size and structure of advanced materials by XRD, SEM, UV-VIS,TEM, STM, AFM etc.	
	APPLICATIONS OF ADVANCED MATERIALS IN CATALYSIS	**(03 Hours)**
	Advanced catalyst preparation methods and applications, Aspects involved in aqueous methods of advanced materials, co-precipitation,	
	APPLICATIONS OF ADVANCED MATERIALS IN EMERGING ENERGY SECTORS	**(09 Hours)**
	Advanced materials synthesis and thin film preparation for energy sectors, various types of thin film synthesis methods, Coater and CVD, aspects and controlling operating parameter involved, Applications of advanced materials in Energy sectors such as various types of solar cell., Applications of advanced materials in various types of fuel cell, water splitting, energy storage etc.	

Zarita, [illegible]

	parameter involved, Applications of advanced materials in Energy sectors such as various types of solar cell., Applications of advanced materials in various types of fuel cell, water splitting, energy storage etc.	
	ADVANCES PROCESS AND PROCESS EQUIPMENT	**(10 Hours)**
	Advances process, Multicomponent distillation column design, Methods including Heuristics for Best sequence selection, Column Design for Distillation and Absorption, optimum design, parameter optimization etc. Computer aided design of chemical process equipment's	
	SEPARATION METHOD SELECTION AND EQUIPMENT SELECTION	**(04 Hours)**
	Separation process selection criteria's and general thumb rules, equipment selection criteria's and general thumb rules	
	HEAT INTEGRATION AND HEAT EXCHANGER NETWORK DESIGN	**(09 Hours)**
	Heat integration, Pinch technology, and Optimum number of heat exchanger and its design	
		(Total Contact Time: 45 Hours)

3.	**Tutorials (Not Applicable)**

4.	**Practical (Not Applicable)**

5.	**Books Recommended**
1	Jastrzebski, Z. D., Nature and Properties of Engineering Materials, John Wiley & Sons, 2nd Edition, 1976.
2	Douglas J., "Conceptual Design of Chemical Processes", McGraw-Hill, New York, 1989.
3	Smith, W.F., Hashemi, J. and Prakash, R., Materials Science and Engineering, McGraw Hill, 4th Edition, 2010.
4	Smith R., "Chemical Process Design", McGraw-Hill, New York, 2nd Edition, 2016.
5	W.D.Sieder, J. D. Seader, D.R. Lewin, "Product and Process Design Principles", John-Wiley, New York, 4th Edition, 2016.

ANNEXURE 3

Elective: Petrochemical Technology

CH364

Scheme

L	T	P	Credit
3	0	0	03

---

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Identify the origin, accumulation and types of petroleum.
CO2	Explain the process of fractionation of crude oil and identify the specifications required for good quality petroleum product.
CO3	Discuss the production process of various types of petrochemical products.
CO4	Describe the operation of various petrochemical industries and process parameters for petrochemical production.
CO5	**Describe safety and environmental aspects in petrochemical industries.**
CO6	**Apply subject knowledgeto solve problems arising in various petrochemical industries.**

2. Syllabus:

- **ORIGIN OF PETROLEUM AND INTRODUCTION TO PETROCHEMICALS (4 Hours)**
  Originof petroleum, Classification of crude, Composition of crude, Types of refineries and refinery products, Raw material for organic chemical industries, Profile of petrochemical industry and its structure.

- **UNIT PROCESSES AND PETROCHEMICAL PROCESSING (6 Hours)**
  Unit processes in petrochemical industries and applications, Nitration and derived chemicals like nitrobenzene, nitrotoluenes, Halogenation and derived chemicals like DCM, MCA, VCM, chlorobenzene, Esterification and production of C1 to C4 alcohols.

- **PRODUCTION OF OLEFINS AND DERIVATIVES (10 Hours)**
  Naphtha and gas cracking for production of olefins, Recovery of chemicals from FCC and steam cracking, Ethylene derivatives: Ethylene Oxide, Ethylene glycol, Vinyl chloride, Propylene and Propylene oxide.

- **PRODUCTION OF AROMATICS AND SPECIALTY PRODUCTS (10 Hours)**
  Aromatics separation train, Aromatics product profile - Benzene, Toluene, Xylene, Ethyl benzene & Styrene, Cumene and phenol, Bisphenol, Aniline, Specialty products likeindustrial grease- Manufactureof calcium grease, Liquid paraffin and petroleum jelly. Polymer gasoline: Feed stock and reactions of polymer gasoline.

- **PRODUCTION OF POLYMERS, ELASTOMERS AND FIBERS (12 Hours)**

Polymers: Polyethylene, Polypropylene, Polystyrene, Polyvinylchloride, polycarbonate, Thermoset resin: phenol formaldehyde, ureaformaldehyde and melamine formaldehyde Elastomers: Styrene Butadiene Rubber(SBR), Poly butadiene, Nitrile rubber, **Polymides or Nylons (PA), DMT and Terephthalic acid, Polyester, Acrylic fibre, Modified acrylic fibre, Acrylonitrile, Acrolein, Viscose rayon and Acetate rayon.**

(Total Lecture Hours: 42)

3. Books Recommended:

1. Groggins P.H., 'Unit Processes in Organic Synthesis', Tata McGraw Hill, 5th Edition, 1995.
2. Chauvel A. and Lefebvre G., 'Petrochemical Processes - I' Gulf Publication; 1st Edition, 1989.
3. Mall I.D., 'Petrochemical Process Technology', Macmillan India Ltd., 2007.
4. Rao M. Gopala, Marshall Sittig, 'Dryden's Outlines of Chemical Technology', East West Press, 3rd Edition, 1997.
5. Wiseman P., 'Petrochemicals,' Ellis Horwood Ltd., 1986.

Elective: Petroleum Refinery Engineering **Scheme**

CH366

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Demonstrate characteristics of crude oil
CO2	Categorize crude before refining
CO3	Explain characteristics of refinery products
CO4	Demonstrate primary and secondary processing required for crude
CO5	Identify different products from primary and secondary processes
CO6	Summarize all the refining processes and effect of the process variables on conversion

2. Syllabus:

- **INTRODUCTION** **(2 Hours)**
  Overall Refinery Flow

- **PRODUCTS** **(3 Hours)**
  Low-Boiling Products, Distillate Fuels, Heating Oils, Residual Fuel Oils and their specification and applications.

- **REFINERY FEEDSTOCKS** **(3 Hours)**
  Crude Oil Properties, Composition of Petroleum, Crudes Suitable for Asphalt Manufacture, Crude Distillation Curves like ASTM, TBP, EFV

- **CRUDE DISTILLATION** **(4 Hours)**
  Desalting Crude Oils, Atmospheric Topping Unit, Vacuum Distillation, Auxiliary Equipment

- **COKING AND THERMAL PROCESSES** **(4 Hours)**
  Types, Properties, and Uses of Petroleum Coke, Process Description—Delayed Coking, Flexicoking, Fluid Coking, Yields from Flexicoking and Fluid Coking, Visbreaking.

- **CATALYTIC CRACKING** **(4 Hours)**
  Fluidized-Bed Catalytic Cracking, Cracking Reactions, Cracking Catalysts, FCC Feed Pretreatment, Process Variables, Heat Recovery

- **CATALYTIC HYDROCRACKING** **(4 Hours)**
  Hydrocracking Reactions, Feed Preparation, Hydrocracking Process, Hydrocracking Catalyst, Process Variables, Hydrocracking Yields.

- **HYDROPROCESSING AND RESIN PROCESSING** **(4 Hours)**

Composition of Vacuum Tower Bottoms, Processing Options, Hydroprocessing, Expanded-Bed Hydrocracking Processes, Moving-Bed Hydroprocessors, Solvent Extraction.

- **HYDROTREATING** **(3 Hours)**
  Hydrotreating Catalysts, Aromatics Reduction, Reactions, Process Variables, Construction and Operating Costs

- **CATALYTIC REFORMING AND ISOMERIZATION** **(4 Hours)**
  Reactions, Feed Preparation, Catalytic Reforming Processes, Reforming Catalyst, Reactor Design, Yields and Costs, Isomerization

- **ALKYLATION AND POLYMERIZATION** **(4 Hours)**
  Alkylation Reactions, Process Variables, Alkylation Feedstocks, Alkylation Products, Catalysts, Hydrofluoric Acid Processes, Sulfuric Acid Alkylation Processes, Comparison of Processes, Alkylation Yields and Costs, Polymerization.

- **PRODUCT BLENDING** **(3 Hours)**
  Reid Vapor Pressure, Octane Blending, Blending for Other Properties.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. James H. Gary, Glenn E. Handwerk, Mark J. Kaiser, "Petroleum Refining Technology and Economics", 5th Edi., CRC Press 2007
2. W. L. Nelson, *Petroleum Refinery Engineering*, 4th Ed, McGraw-Hill Book Company, New York, 1958.
3. David S.J. Jones, Peter R. Pujado, "Handbook of Petroleum Processing", 1st Ed., Springer Publication, 2008.
4. Rao B.K.B., "Modern Petroleum Refining Processes", 4th Ed., Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 2002, (4th Ed).
5. Mohamed A. Fah Im, Taher A. Alsahhaf, and Amal Elkilani, Fundamentals of Petroleum Refining, 1st Ed., Elsevier, 2009.

Department of Civil Engineering

Vocational Training / Professional Experience
(Mandatory for Exit; and Optional for others)

VOCATIONAL TRAINING (1st Semester)

Construction Site Supervisor
CE XXX **Contact Hours: 200**

Role of Vocational Training:

CSS course trains students with essential skills to excel in the dynamic field of civil construction work. By comprehensively addressing aspects such as project team management, safety protocols, quality assurance, and material testing, the course empowers individuals to ensure the alignment of construction activities with execution standards. The CSS course envisions a professionals capable of supervising construction processes adeptly, contributing to safer, efficient, and sustainable construction practices in the field.

Outcome of the Vocational Training:

By completion of CSS vocational training, students acquire a multifaceted skill set essential for effective construction site supervision. They gain an understanding of agency dynamics, project team management, safety protocols, and quality assurance practices. By mastering techniques of material testing and interpretation of test reports, students enhance their ability to ensure construction quality. Moreover, the training equips them to prepare crucial site documentation, promoting organized project management. The outcome of CSS training culminates in a skilled professional that can collaboratively ensure timely project completion, maintain high-quality construction standards, and effectively manage risks and emergencies, thereby contributing significantly to the civil construction industry's advancement.

Course Outcomes (COs):

At the end of the course, students will be able to:

CO1	To collaborate with different agencies involved in the construction site to ensure timely project completion.
CO2	To study architectural and structural drawings; inspect and monitor the construction site.
CO3	To supervise construction processes, materials, and equipment to ensure alignment with execution standards and engage in discussions about supervision methods and performance evaluation techniques.
CO4	To contribute to controlling work quality, progress and cost at Construction Site.
CO5	To manage and mitigate various types of hazards, accidents and emergencies associated with the workplace and their prevention measures.

1. **To develop understanding of construction site organization** **(10 Hours)**
Working of various agency like client, contractor, consultant, supplier, various engineer, supervisor, team members, Responsibility of site staff

2. **To understand the project team and its management** **(20 Hours)**
Preparation of inventory data from working drawings like Planning team, design team, construction team, supporting agencies, civil site silent features, working time period, specialization work and billing

3. **Practice for safety on site** **(15 Hours)**
Safety rules and guidelines for construction site, current practice on site, good practice, Site staff program (In house training), safety tools and equipment, first aid kit, responsibility in case of accident

4. **Practice for Material testing** **(35 Hours)**
Type of tests for different construction materials like fine aggregate, coarse aggregate, cement, steel, water as well as concrete like workability, preparation of cube, its norms and standards

5. **Supervision of Civil construction work** **(45 Hours)**
Learning of site set up, day to day working and check list for supervision of civil construction work like excavation, brick masonry, shuttering and centering, reinforcement, concrete, plaster, flooring, method of preparation of construction schedule

6. **Supervision of services** **(25 Hours)**
Learning of different services like water supply, drainage, electric work

7. **Good practice for quality assurance** **(20 Hours)**
Learning water cement ratio, curing period for different work like brick masonry, plaster, concrete, etc. learning of test frequency of different material and concrete cube

8. **Practice for interpretation of test report** **(10 Hours)**
Learning of different test report interpretation for different materials like fine aggregate, coarse aggregate, cement, steel, water, etc.

9. **Practice for preparation of document for construction site** **(20 Hours)**
Understanding of daily report, preparation of site register like materials received on site, test report file, weekly progress report file, site observation and comply register, working drawing file, structural drawing file, submission of report, record to be maintained on site

CO-PO-PSO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	0	2	0	1	3	1	3	3	3	3	2	2	3	2
CO2	3	1	1	1	0	0	0	2	1	2	1	3	1	2	3
CO3	0	2	2	2	3	2	1	3	2	3	3	2	1	3	3
CO4	3	1	3	1	1	3	2	3	2	2	2	3	3	1	2
CO5	0	1	0	0	0	3	3	2	1	0	2	2	1	3	1

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Department of Civil Engineering

Vocational Training / Professional Experience

(Mandatory for Exit; and Optional for others)

VOCATIONAL TRAINING (1st Semester)

Surveyor

CE XXX Contact Hours: 200

Role of Vocational Training:

The aim is to train the students in the fieldwork of Survey. Student must be able to determine out line, contours and relative position of control points (land marks) on tract of land, coast, harbour, etc. for preparing topographical and other maps as well as records. A method of establishment of control points and pillars to do instrumentation work on ground to prepare maps is also essential to know for the student.

Outcome of the Vocational Training:

After completing the vocational training, student will able to develop skills related to detect and resolve issues during execution. Demonstrate possible solutions and agree tasks within the team. Communicate with required clarity and understand technical English. Sensitive to environment, self-learning and productivity. Perform TPM (Total Production Management), TQM (Total Quality Management) and record keeping system.

Course Outcomes (COs):

At the end of the course, students will be able to:

CO1	Read and interpret technical parameters/document, plan and organize work processes, identify necessary materials and tools
CO2	Perform task with due consideration to safety rules, accident prevention regulations and environmental protection stipulations
CO3	Apply professional skill, knowledge, core skills & employability skills while performing jobs and solve problem during execution
CO4	Check the job/assembly as per drawing for functioning, identify and rectify errors in job/assembly
CO5	Document the technical parameters related to the task undertaken.

Deepesh

1. **Familiarization with the Field Work** **(15 Hours)**

Importance of trade training, instrument and equipment's used, nature of job done by Surveyor. Drawing different types of lines, printing letters and figures. Construction of plane scales.

2. **Conventional signs and symbols used in survey** **(15 Hours)**

Topography and building drawing. Map reading practice, contour, drainage etc.

3. **Procedure in Conducting Chain Survey on Plane Ground** practice in unfolding and folding chain, errors and adjustment of chains, alignment, chaining lines, measurement of distances and booking. Practice in chaining, taking offset, uses of optical square and cross staff. Setting out right angles and booking. Testing a chain, tape, optical square and cross staff. locating details, booking and plotting **(30 Hours)**

4. **Procedure in Conducting Chain Survey on Sloping Ground** **(30 Hours)**

Taking horizontal measurement on sloping ground, overcoming obstacles, measuring distance between two points invisible from each other. Inking and coloring the plotted map. Surveying of tank, a rout or obstructed field by chain traverse, method of finding height of inaccessible objects.

5. **Conduction of Traverse with the Plane Table** **(25 Hours)**

Setting up plane table, leveling, centering and orientation. Surveying an area with plane table by radiation and Intersection methods. Traversing with plane table of built up areas and fixing details.

6. **Conduction of Traverse with the Chain and Compass** **(40 Hours)**

Practice in setting up compass and checking its accuracy taking bearings and calculating angles. Determining the bearings of a given line and establishing lines of given bearings, laying out rectilinear and polygonal plots of ground using compass and tape. Conducting closed traverse of built up fields and plotting the same.

7. **Evaluation of Profile of Existing Ground** **(45 Hours)**

Practicing simple leveling, differential leveling, reciprocal leveling, fly leveling, longitudinal sectioning, cross sectioning and check leveling. Reduction of levels, Preparation of sections and working profiles. Setting out gradients.

CO-PO-PSO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	0	1	0	1	0	3	2	1	3	1	2	0	2
CO2	0	0	2	1	1	3	3	2	2	3	1	2	2	2	2
CO3	3	3	3	2	0	2	2	2	1	3	2	2	3	2	2
CO4	0	2	3	2	3	2	1	2	3	2	3	2	1	3	3
CO5	1	0	0	2	2	1	3	3	1	2	3	3	1	2	3

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Annexure 67.13
of 67th meeting of the IAAC

Annexure -3

Sardar Vallabhbhai National Institute of Technology, Surat

CE 402
INDUSTRIAL INTERNSHIP

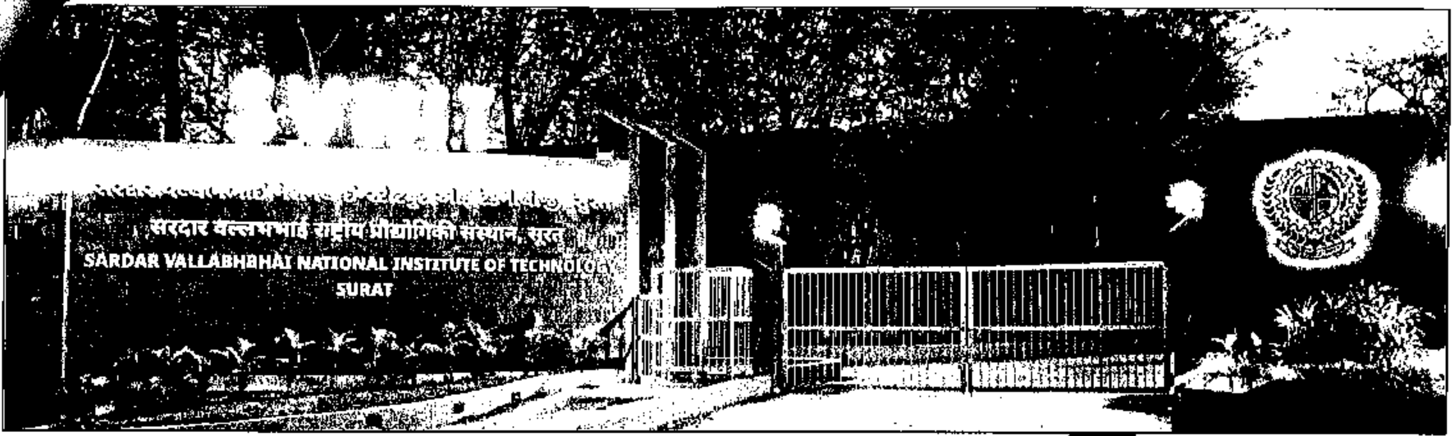
STANDARD OPERATING PROCEDURE

INTERNSHIP CELL

Dr. R. A. Christian
Professor & Head of Department, DoCE
Email : industrialinternship@ced.svnit.ac.in
Contact : 0261-221841

Internship Co-Ordinator
Dr. Chetankumar R. Patel
Associate Professor
DoCE, SV-NIT

INDEX



About **SVNIT**

This Institute was established in 1961 as one of the RECs for imparting technical education in Civil, Mechanical and Electrical Engineering. In the year 1983-84 the Under Graduate programmes in Electronics Engineering was introduced and in the year 1988-89 the UG programmes in Computer Engineering and Production Engineering was started. In the year 1995-96, UG programme in Chemical Engineering was introduced. In exercise of the powers conferred by section 3 of the University Grants Commission (UGC) Act, 1956, the Central Government on the advice of the University Grants Commission, has declared the Sardar Vallabhbhai Regional College of Engineering & Technology (SVREC), Surat to Sardar Vallabhbhai National Institute of Technology (SVNIT), Surat with status of "Deemed University" with effect from 4th December 2002. The Institute has been granted the status of 'Institute of National Importance' w.e.f. Aug. 15, 2007. At present, the Institute is offering Six UG Programmes, Nineteen PG Programmes and Three M.Sc. Five Years Integrated Programme including doctoral programme in all above branches.

Director **Message**

"My vision is to improve the NIRF and Global ranking of SVNIT, Surat and provide the comprehensive and integrative education and carry out quality research in Engineering, Science and Technology for bestowing nation development in line with National Educational Policy (NEP) 2020."

HOD **Message**

"Students have to master the skill to apply the technical knowledge in field conditions. Industrial internship exposes the students to field conditions and trains them to apply the technical knowledge gained to field problems."

Institute Vision , Mission & Objectives

Vision

Sardar Vallabhbhai National Institute of Technology (SVNIT), Surat, perceives to be a globally accepted centre of excellence in technical education catalyzing absorption, innovation, diffusion and transfer of high technologies resulting in enhanced quality for all the stakeholders.

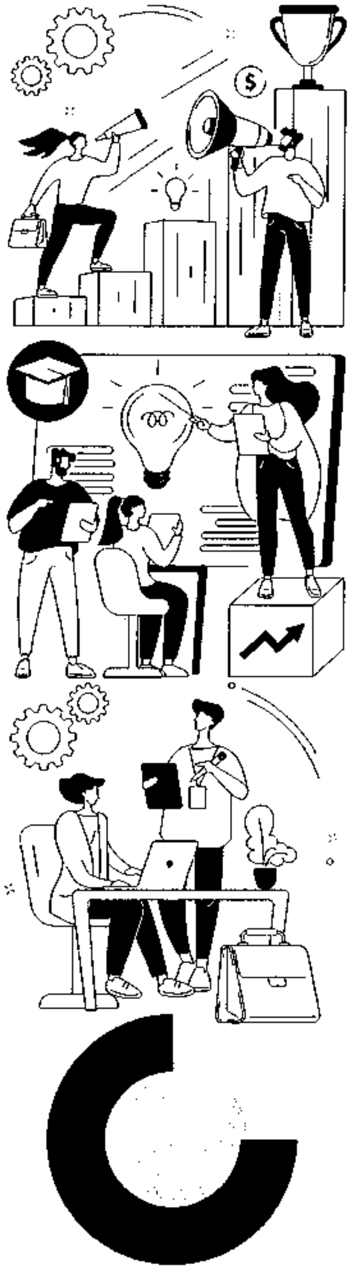
Mission

The mission of the Sardar Vallabhbhai National Institute of Technology (SVNIT), Surat is to be a leading technical Institute not only at national level but also at International level for imparting training to manpower as per the needs of technology. It is also envisaged to provide the necessary infrastructure to take up research work and to provide the mechanism to interact with industries effectively.

Objectives

- To offer quality programmes in the engineering at UG, PG and Ph.D.level.
- To impart instruction and training to students to meet the technological needs.
- To promote research environment.
- To promote Industry – Institute interaction.
- To foster national integration and value based education.
- To interact with Alumni for development of the Institute and for making use of their expertise and resources.
- To impart quality education alongwith development of confidence for being an entrepreneur.
- To inculcate environment Innovations amongst students.

CE 402 **Industrial Internship**

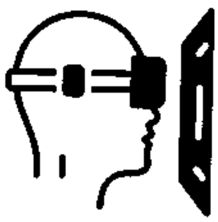


Preamble

CE 402 Industrial Internship, provides prospects to see how the theoretical aspects learned during the course work are extended/integrated/applied in the real field conditions. Undergoing the internship students may get On-floor experience which provides a much better professional experience. Also it provides an opportunity to be hired by the industry/organization. CE402 is the 20-credit course to be completed in the duration as mentioned in the academic calendar of the respective year. To understand how to approach and explore the opportunity in their chosen field, student will go through the rigours process and select the company for the fulfilment of the course requirement.

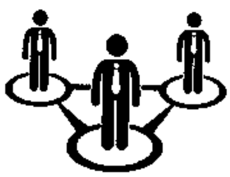
The Department of Civil Engineering (DoCE) will also help the students to be place for the Industrial Internship based on the merits and choice of discipline. The students have to adopt the Standard Operating Procedure (SOP) as describe in the document and has to follows the safety Guidelines and norms as per the appendix IV.

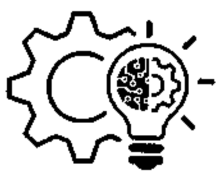
Industrial Internship
Objectives



- Exposure to technical students to the industrial culture, which cannot be simulated in the classroom.
- Exposure to the current technological developments relevant to the subject area provides opportunities to learn, comprehend and improve real-time technical/managerial skills.
- Acquaintance with various materials, processes, products, and their applications, along with the relevant aspects of quality control.

- Understand the social, economic, and administrative considerations that influence the working environment of industrial organizations. In addition, the psychology of the workers and their habits, attitudes, and approach to problem solving.
- Learn to apply the technical knowledge in real industrial situations and use the experience in writing technical reports/projects.

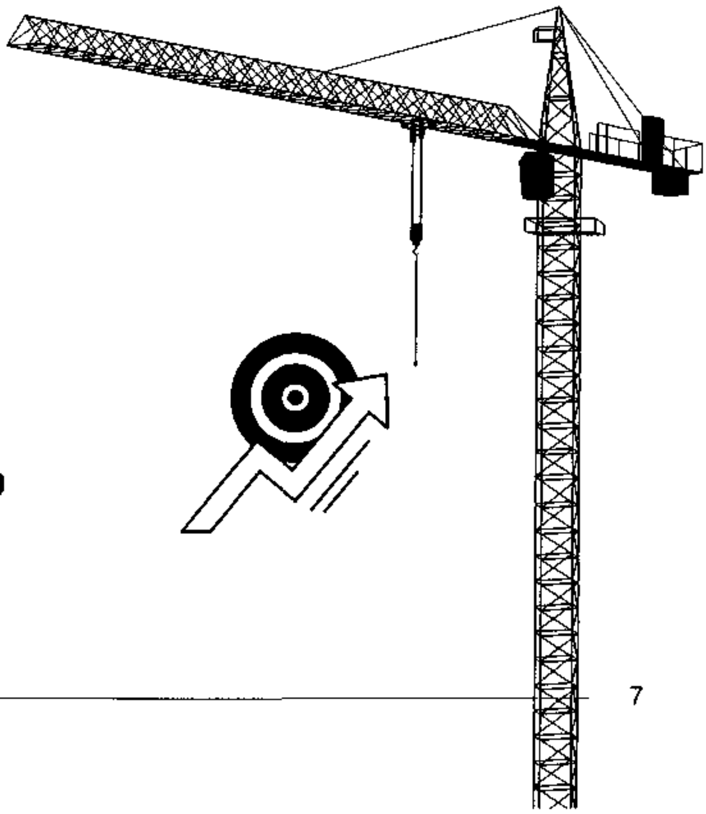




CE 402
Industrial Internship
Course Outcomes (COs)

At the end of the industrial internship the students will be able to:

- **CO1:** Provide potential opportunities to learn understand and sharpen the real-time technical/managerial skills required at the job.
- **CO2:** Comprehend the psychology of the team members, their habits, attitudes, and approach to problem-solving
- **CO3:** Apply the technical knowledge gained during the course to solve real field problems.
- **CO4:** Compile the information in connection with the task accomplished during the industrial training in the form of a report.
- **CO5:** Contribut to Professional Development.



CE 402
Industrial Internship
Rubrics

CRITERIA	NOT ACCEPTABLE - POOR (0% - 25%)	BELOW EXPECTATIONS - AVERAGE (25% - 50%)	MEET EXPECTATIONS - GOOD (50% - 75%)	EXCEEDING EXPECTATIONS - EXCELLENT (75% - 100%)
Company Background & Training Description	• Little overview and explanation • Local contractor/ firm	• Brief but incomplete overview and limited explanation • Local contractor/ firm	• Thorough but sufficient company overview and training objectives and scope are defined. • Reputed firm established as a company, R&D organizaton, Research institute	• Extensive company overview, including some history, projects, clients, and well-defined training objectives and scope. • Reputed firm established as company , R & D organization, research institute, and national and international repute
Reflection - Positive and Negative Aspects	• Little reflection	• Some reflection	• Honest reflection but less insight and attention to detail	• Insightful and honest reflection of each, giving attention to detail
Contribution to Professional Development	• Little explanation	• Some explanation	• Insightful, thought-provoking, but not including an explanation of "how" and "why" there was or could have been a positive contribution to professional development	• Insightful, thought-provoking, including an explanation of "how" and "why" there was or could have been a positive contribution to professional development
Report Preparation	• The format and flow of content are not in logical sequence	• Either format or flow of content is not in a logical sequence	• Format and flow of content are both acceptable	• The format and flow of content are in logical sequence and are well defined
Technical and Managerial Skill/ Knowledge Gain	• Little or no knowledge gain	• Some knowledge gain and improvement to the existing know-how	• Significant knowledge gain	• Significant knowledge gain and application of the technical knowledge and offered a PPO

CE 402
Industrial Internship

Students have to adopt following SOP:

1. Identification of Internship Opportunities:

- Students shall actively research and identify potential internship opportunities with National/State/Local Government agencies or Private Agencies in the Civil Engineering field in liaison with DoCE
- Students may utilise various sources, including the Institute Career Development Cell, faculties of DoCE, alumni, job portals, through networking, and direct applications to organisations.

2. Internship Duration:

- The internship should be between **First day of Teaching to Last day of Teaching** as per respective academic calendar.

3. Submission of Internship Request:

- Students must submit their internship requests or applications to the selected organizations and confirm the same before **One Month to start of the Internship**. This may include a cover letter, resume, and other required documents.

4. Acceptance Letter to Internship Coordinator:

- Once selected for an internship, students must submit an acceptance letter to the Internship Coordinator on or before **One Month to start of the Internship.**
- Department will appoint a Mentor for the Internship and students has to communicate regularly with the Mentor.
- DoCE will also extend the support to the students as necessary from time to time, to complete the CE 402 Industrial Internship requirement.
- The acceptance letter should include details of the internship, including the organisation's name, contact details and internship start and end dates ensuring alignment with the academic schedule.

5. Terms to be used for any communication:

- Organisation/ Firm: to be used while referring to a place. Where working as an intern (Company under which you are doing internship)
- Institute: To be used while referring to SVNIT, Surat.
- Internship Supervisor: Person at Firm / Organisation, under whom pursuing internship.
- Internship Mentor: Faculty of DoCE allotted to the student.
- Internship Coordinator: Overall coordinator of Internship Program, a faculty member of DoCE.

CE 402
Industrial Internship

6. Declaration of stipend (if any) received from organisation/ firm during an internship:

- The B. Tech. IV students are instructed to provide a Declaration of Stipend (if any offered by the Organisation / Firm) to the institute through email to the Internship Co-ordinator of Department of Civil Engineering. This is to be done to avoid any discrepancies.

7. All correspondence:

- For proper documentation and smooth functioning of work all correspondence will be done email industrialinternship@ced.svnit.ac.in only.
- Subject title and file name for weekly/monthly/final report submission: (CE402_ 2024_Roll No of Student_Report No._)

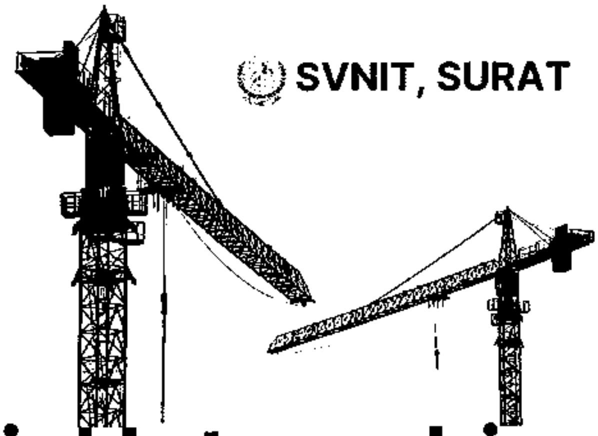
8. Weekly report:

(A) Submit the Weekly report to:

- The Internship Mentor (Institute mentor and Internship Supervisor)
- CC to Internship Co-ordinator for Continuous Assessment
- Email from the Internship Supervisor to be sent to the Institute, confirming the work claimed in the weekly report.

(B) Weekly Report Submission:

- Throughout the internship, students should maintain a record of their daily activities, accomplishments and submit weekly reports along with attendance signed by supervisor in the prescribed format (Appendix I & II).
- Students should submit weekly report on areas to be addressed during training as prescribed format (Appendix III).
- The weekly report is to be mandatorily submitted every week on Saturday evening (latest by 11:59 pm).
- The confirmation of the report from the organisation/ firm is mandatory, through email.

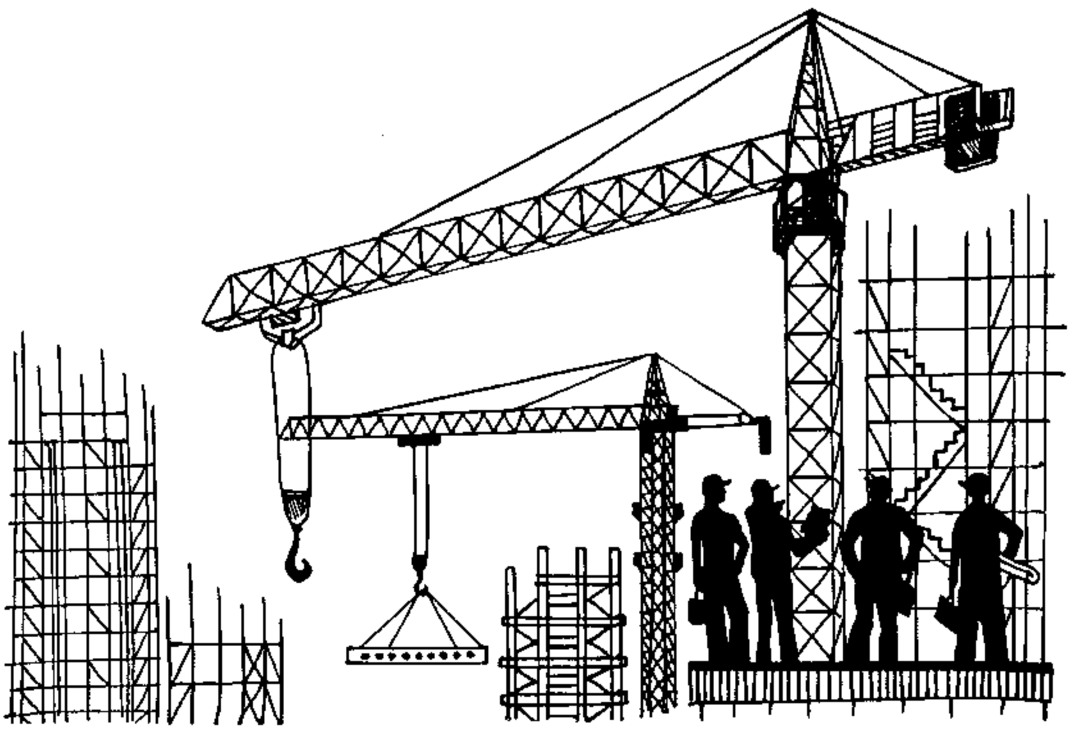


9. Internship Report Submission:

- A Draft report must be submitted at the end of the internship (Appendix II).
- Student must be available in the campus **within the week of the completion of internship as per the schedule of academic calendar.**
- A final report must be submitted on **the first day of the end semester examination / as per the schedule of academic calendar.** This report should be submitted in both hard and soft copy formats.
- Students are required to present their internship experiences and findings during **the end semester exam slot as per the respective academic calendar.**

10. Communication:

- Looking at the different locations of Interns & faculty members, communication is key to creating workability.
- Feel free to communicate through call/WhatsApp Group/SMS/E-mail for training and development during the CE 402 Industrial Internship.
- Follow good administrative practices and safety norms.



Appendix I

DEPARTMENT OF CIVIL ENGINEERING, SVNIT, SURAT

B. Tech- IV (Civil Engineering), Semester VIII, Year- 2024

CE 402 Industrial Internship Weekly Report

Report Duration: __/__/2024 to__/__/2024 **Week No: 1st**

Name of Scholar:	Roll.no.:
Name of Firm:	Location:
Name of Internship Supervisor / Designation:	Email ID/Mobile No:

Details of work:

Sr. No.	Date	Day	Work details	Learning from work (One paragraph: 07 to 10 lines)	Details of Attachments in E-mail (Plan, Map, Research Paper, Photographs, etc...)
1.		Monday			
2.		Tuesday			
3.		Wednesday			
4.		Thursday			
5.		Friday			
6.		Saturday			

Scholar Signature (With Date):

Internship Supervisor's Signature (With Date):

Company Seal

Appendix II

DEPARTMENT OF CIVIL ENGINEERING, SVNIT, SURAT

B. Tech- IV (Civil Engineering), Semester VIII, Year- 2024

<u>Weekly Attendance Sheet</u>

Report Duration: __/__/2024 to__/__/2024 **Week No: 1st**

Name of Scholar:	Roll.no.:
Name of Firm:	Location:
Name of Internship Supervisor / Designation:	Email ID/Mobile No:

Date	Day	Signature of Scholar
	Monday	
	Tuesday	
	Wednesday	
	Thursday	
	Friday	
	Saturday	

Scholar Signature (With Date):

Internship Supervisor's Signature (With Date):

Company Seal

Appendix III

Sardar Vallabhbhai National Institute of Technology, Surat

DEPARTMENT OF CIVIL ENGINEERING

B. Tech-IV (Civil Engineering), Semester VIII, Year 2024

CE 402 Industrial Internship/ Training

Areas to be addressed during training (as per institute norms)

Area 1: Introduction

- Need for Industrial Internship
- Internship Location (City) (Brief description)
- Objective of Training (Number: 02 to 04 only)
- Framework of training (Flowchart)
- General Details:
- Training report Chapter Details (Title, Brief details: 2 to 3 lines only)

Area 2: Interview of Internship Supervisor (Submission: End of the 2nd week) (Soft copy)

- General Details:
  - Name of Internship Supervisor
  - Designation of Internship Supervisor
  - Contact details of Internship Supervisor
  - Qualifications of Internship Supervisor
  - Experience of an Internship Supervisor
- Motivation behind working in this occupation
- Professional strengths of the person
- Projects handled so far
- Professional grey areas and how they overcome these grey areas
- Contribution to Society through profession
- Contribution to the city as a professional (Memberships in different organisations, etc)
- Take away points from their profession
- Photographs: Interaction with Internship Supervisor
- Photographs: Office Building
- Location Map of your Internship office

Note: Any other important point (which can be addressed)

Area 3: About the Site /Project (Brief Details) (Submission: End of the 3rd week) (Soft copy) (As per the site and project)

- History of the city
- Demography (Census data, project the population for the next 10 years)
- Physical growth of the city
  - TP / DP of the city (History of DP, no. of DP, etc...)
  - Planning Units
  - Spatial growth

- Land use plans
- Details of academic institute/planning unit within the city
- Socio-Economic structure
- Existing Scenario of Major Infrastructure
- Smart City projects
- Special Projects in the city
- Transportation projects, green mobility, etc...
- Other relevant Civil Engineering details of the city

Note: Any other important point (which can be addressed)

Area 4: About Firm/ Organization (Submission: End of the 4th week) (Soft copy)

- Name of Firm /Address/ Contact Details
- Visiting card, Website, Brochure, etc...
- History of the Firm/ Organisation
- Organisational Setup (Staff structure)
- Firm Governmental Details
- License/ Approvals for the firm
- Role of Employees in the firm with their designations (Role of Engineers)
- Monthly Establishment details (expenditure details) (If they provide)
- Projects of the firm:

Note: Any other important point (which can be addressed)

Area 5: Industrial Internship Work (Actual learning by scholar):
(Part submission: From the end of the 5th to 7th week) (Soft copy)

- Detail of project (All salient features supported with maps)
- No overlap if scholars are more than 02 (Two) in the same firm
- Explanation of Study/ Review/Planning/ Designing work done by the student
- Pre-activity related to the Project
  - How did the firm get information regarding the project?
  - Qualification requirements for the firm to get the project? (Details regarding
  - Professional setup, Infrastructure setup, etc.)
  - How did the firm get the project?
  - Field Visits/ Survey details related to the project (before getting the project
  - Presentation to Authorities regarding the project.
  - How was the work awarded to the firm?
- Actual Work
  - Site Visits mandatory (Follow the safety rules/measures)
  - Meeting details related to the project staff on-site and office representative
  - Working methodology for the project (Work approach, methods used, work done, etc.)
- Post-completion Activity
  - Documentation process of the project
  - Submission process of the project
  - Handover-take over method of project
  - Final Financial bills

Note: Any other important point (which can be addressed)

Area 6: Appendix

- Correspondence papers (request letter/ Confirmation mail and Completion Certificate)
- Weekly reports and weekly photographs (Minimum 05 no.) (prescribed format)
- About Organisation/ Firm (if any Brochure or details)
- Important Inventory Data of Project documents (drawings, Reports etc.)
- Local Newspaper cuttings/ plates
- Important Government Documents (if any referred)
- Photographs (Meetings with office staff, Internship supervisor, resource person within the city, site visit etc.)

Note: Any other important point (which can be addressed)

Appendix IV

Guidelines for Students

Safety of the students is of utmost importance during internship in any organization. Students must adhere to strict safety guidelines to protect themselves and others. Here are safety guidelines the students are required to adhere throughout the Industrial Internship (CE 402).

1. It is mandatory for all the students to submit the safety and health undertaking which is duly signed by Parents before the internship. (**Appendix: A**)
2. Students are required to submit the medical fitness certificate filled by the medical professional describing the medical conditions of particulars (If Any) (**Appendix: A**).
3. Students having acrophobia, aquaphobia or any other medical condition which they might encounter while performing certain activities are advised to refrain performing such activities and inform the same to your accompanying faculty.
4. It is mandatory for the students to carry and wear the college or organization I-cards or compulsory during the internship.
5. Students must acclimatize themselves with site conditions and must avoid wandering the areas with potential hazards.
6. Students must avoid distractions such as using phones or headphones during internship.
7. It is mandatory for students to pay attention to safety briefing before visiting the project site. The students must familiarize themselves with the location of fire extinguishers and emergency exits, site's emergency procedures which includes evacuation routes and assembly points.
8. Students are instructed to stay within the demarcated boundaries and follow designated walkways and pathways.
9. Students are advised to avoid wearing loose clothing which may get caught in machinery.
10. During site visits, it is mandatory for the students to wear personal protective equipment's (PPE) which Include but not limited to the following items.
    a) Safety Helmet to protect against falling objects.
    b) Safety Shoes to protect feet.
    c) Safety goggles or glasses to protect eyes from debris.
    d) High-visibility vests for visibility.
    e) Ear protection if there is loud machinery or equipment.
11. If you notice any safety hazard on site, students are instructed to report the same to higher authorities as soon as possible.
12. Disciplinary action will be taken against the student if he/she fails to comply with the above-mentioned guidelines.

Signing the Appendix 'IV' and Appendix A and B declares that I have gone through all the guidelines which are binding on me for my safety during the internship. The Institute will not be responsible for any hazard and accidents caused due to my sole negligence.

Name of Student & Signature

Date: / /202

Appendix: A Undertaking Form

Undertaking by the Student Regarding Safety protocols to be followed during the Industrial Internship (CE 402)

I, ____________________________________, a Student of Sardar Vallabhbhai National Institute of Technology, Surat, having admission number __________ in Department of Civil Engineering acknowledge that I am pursuing the internship to fulfil the requirements of the course 'Industrial Internship (CE 402)' offered in semester VIII of B Tech (Civil Engineering). In doing so, I am joining an organization/a project ____ to obtain training from __________to ____________. I understand and agree to the safety guidelines and rules attached in **Appendix IV** to ensure my safety and the safety of others during this Industrial Internship (CE 402).

I understand that my participation in the industrial internship is voluntary, and I am aware of the potential risks involved. By signing this undertaking, I agree to abide by the safety guidelines and rules outlined in the Annexure A & B below to ensure a safe and productive industrial internship as declared to the institute.

Student's Full Name :

Entry number : **Age (years):**

Student's Mobile Number :

Student's Institute Email :

Blood Group :

Parent's Full Name :

Emergency Contact Number :

Parent's Contact Details :

Gurdian's Signature :

Company/organization name :

Mentor from Organization :

Contact no and email :

Student's Signature :

Date and Place :

Appendix: B Medical Certificate

Medical Certificate to be furnished by the medical professional stating the medical condition of students participating in Industrial Internship (CE 402).

I, Dr. ______________________________, certify that I have performed thorough medical examination of a student ______________________________ of Sardar Vallabhbhai National Institute of Technology, Surat, having admission number ____________ of Department of Civil Engineering.

Kindly refer to the medical conditions below (If Any). The Institute will not be responsible for any medical emergencies caused during the Industrial Internship (CE 402).

Medical Condition (If Any):

____

____

Precautionary measures (If Any):

____

Blood Group: ____

Doctor's Full Name: ______________________________

Hospital Name and address: ______________________________

Doctor's Signature: ______________________________

Student's Signature: ______________________________

Date: __/__/202_

Contact

Co-ordinator :

Dr. Chetankumar R. Patel
Associate Professor &
Internship Co-Ordinator

Email : industrialinternship@ced.svnit.ac.in

Contact : +91 9898603853

Annexure 67.17
of 67th meeting of the IAAC

Addmission to M.Tech.(C) (WRE) Existing and Proposed Courses List 2024-2025

S.No.	Institute	Department	PG Program	Group	Qualifying Degree	GATE Paper
Existing	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Agriculture Engineering-(T[illegible])	Agricultural Engineering -(AG)
Existing	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Civil Engineering-(T[illegible])	Agricultural Engineering -(AG)
Existing	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in [illegible] Engineering	Agricultural Engineering -(AG)
Existing	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Water Management-(T[illegible])	Agricultural Engineering -(AG)
Existing	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Agricultural Engineering-(T[illegible])	Civil Engineering -(CE)
Existing	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Civil Engineering-(T[illegible])	Civil Engineering -(CE)
Existing	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in [illegible] Engineering	Civil Engineering -(CE)
Existing	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Water Management-(T185)	Civil Engineering -(CE)
Existing	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Civil and Infrastructure Engineering-(T425)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Environmental Engineering-(T142)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Civil and Water Management-(T396)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Civil and Water Management-(T396)	Agricultural Engineering -(AG)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Environmental Science and Engineering-(T248)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Agricultural and Food Engineering -(T188)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Agricultural and Food Engineering -(T188)	Agricultural Engineering -(AG)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Civil Environmental Engineering-(T[illegible])	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Planning-(T171)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Structural Engineering-(T180)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Town planning-(T1[illegible])	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Transportation Engineering-(T184)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Architecture and Regional Planning-(T193)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Civil Engineering and Planning-(T208)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Civil Technology-(T209)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Computer Aided Design of Structures -(T212)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Construction and Project Management -(T220)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Construction Engineering and Management-(T221)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Construction Technology and Management -(T222)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Town and Country Planning-(T322)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Civil and Transportation Engineering-(T324)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Architecture and Interior Decoration-(T332)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Civil and Transportation Technology-(T336)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Civil Engineering (Public Health Engineering)-(T337)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Facilities and Services Planning-(T345)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Project Management-(T380)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Civil and Infrastructure Engineering-(T425)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Construction Automation-(T481)	Civil Engineering -(CE)

Addmission to M.Tech.(C) (WRE) Existing and Proposed Courses List 2024-2025

S.No.	Institute	Department	PG Program	Group	Qualifying Degree	GATE Paper
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech in Architectural Assistantship-(T499)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Civil and Rural Engineering -(T437)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Civil Engineering with Computer Application-(T439)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Civil Engineering Environment and Pollution Control-(T438)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Civil Engineering (Construction Technology)-(T440)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Civil and Structural Engineering -(T476)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Civil and Environmental Engineering -(T478)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Civil engineering (Environmental Engineering) -(T479)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Civil and Water Management Engineering -(T509)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B Tech. in Agricultural Engineering -(T504)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Agricultural Engineering -(T504)	Agricultural Engineering -(AG)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Agricultural Technology -(T505)	Civil Engineering -(CE)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B.Tech. in Agricultural Engineering -(T504)	Agricultural Engineering -(AG)
Proposed	Sardar Vallabhbhai National Institute of Technology, Surat	Department of Civil Engineering-(CE)	Water Resources Engineering-(WA)	Group I	B.E./B Tech. in Environment Engineering -(T520)	Civil Engineering -(CE)

(Dr J N Patel) 01/05/2024 (Dr P L Patel) (Dr S M Yadav) 1/5/24 (Dr. P. G. Agnihotri) (Dr V Mahetr) 1/5/24 (Dr P V Timbadiya) 1/5/24 (Dr G J Kale) 1/5/24

प्रेमलाल पटेल 06.05.2024

Annexure 67.20
of 67th meeting of the IAAC

MOOC - I & MOOC - II to be offered @ MTech-II - Sem-III - 2024.

Annexure I

Click here to download the sheet

TIMELINE	8 Weeks (SET 1)	12 Weeks	4 Weeks (SET 2)	8 Weeks (SET 2)							
Start of Course	July 22, 2024	July 22, 2024	August 19, 2024	August 19, 2024							
End of Course	September 13, 2024	October 11, 2024	September 13, 2024	October 11, 2024							
noc24-cs86	Distributed Optimization and Machine Learning	Prof. Mayank Baranwal	IIT Bombay	IIT Bombay	12 Weeks	New	July 22, 2024	October 11, 2024	October 26, 2024	July 29, 2024	August 16, 2024
noc24-cs112	Secure Computation: Part II	Prof. Ashish Choudhury	IIIT Bangalore	IISc Bangalore	12 Weeks	Rerun	July 22, 2024	October 11, 2024	November 2, 2024	July 29, 2024	August 16, 2024
noc24-cs99	Advanced Distributed Systems	Prof. Smruti Ranjan Sarangi	IIT Delhi	IIT Delhi	12 Weeks	Rerun	July 22, 2024	October 11, 2024	October 27, 2024	July 29, 2024	August 16, 2024
noc24-cs85	Practical Cyber Security for Cyber Security Practitioners	Prof. Sandeep K. Shukla	IIT Kanpur	IIT Kanpur	12 Weeks	New	July 22, 2024	October 11, 2024	October 26, 2024	July 29, 2024	August 16, 2024
noc24-cs100	Randomized Methods in Complexity	Prof. Nitin Saxena	IIT Kanpur	IIT Kanpur	12 Weeks	Rerun	July 22, 2024	October 11, 2024	October 27, 2024	July 29, 2024	August 16, 2024
noc24-cs87	Computational Arithmetic - Geometry for Algebraic Curves	Prof. Nitin Saxena	IIT Kanpur	IIT Kanpur	12 Weeks	New	July 22, 2024	October 11, 2024	October 26, 2024	July 29, 2024	August 16, 2024
noc24-cs88	Artificial Intelligence : Search Methods For Problem solving	Prof. Deepak Khemani	IIT Madras	IIT Madras	12 Weeks	Rerun	July 22, 2024	October 11, 2024	October 26, 2024	July 29, 2024	August 16, 2024
noc24-cs102	Reinforcement Learning	Prof. Balaraman Ravindran	IIT Madras	IIT Madras	12 Weeks	Rerun	July 22, 2024	October 11, 2024	October 27, 2024	July 29, 2024	August 16, 2024
noc24-cs89	Deep Learning for Computer Vision	Prof. Vineeth N Balasubramanian	IIT Hyderabad	IIT Madras	12 Weeks	Rerun	July 22, 2024	October 11, 2024	October 26, 2024	July 29, 2024	August 16, 2024
noc24-cs117	Parameterized Algorithms	Prof. Neeldhara Misra Prof. Saket Saurabh	IIT Gandhinagar and IMSc - The Institute of Mathematical Sciences	IIT Madras	12 Weeks	Rerun	July 22, 2024	October 11, 2024	November 3, 2024	July 29, 2024	August 16, 2024
noc24-cs104	Applied Accelerated Artificial Intelligence	Prof. Satyajit Das Prof. Satyadhyan Chickerur Prof. Bharatkumar Sharma Prof. Adesuyi Tosin	IIT Palakkad KLE Technological University NVIDIA	IIT Madras	12 Weeks	Rerun	July 22, 2024	October 11, 2024	October 27, 2024	July 29, 2024	August 16, 2024
noc24-cs90	Social Network Analysis	Prof. Tanmoy Chakraborty	IIT Delhi	IIT Delhi	12 Weeks	Rerun	July 22, 2024	October 11, 2024	October 26, 2024	July 29, 2024	August 16, 2024
noc24-cs91	Software Testing	Prof. Meenakshi D'souza	IIIT Bangalore	IIT Madras	12 Weeks	Rerun	July 22, 2024	October 11, 2024	October 26, 2024	July 29, 2024	August 16, 2024
noc24-cs106	Computational Complexity	Prof. Subrahmanyam Kalyanasundaram	IIT Hyderabad	IIT Madras	12 Weeks	Rerun	July 22, 2024	October 11, 2024	October 27, 2024	July 29, 2024	August 16, 2024
noc24-cs121	Cyber Security and Privacy	Prof. Saji K Mathew	IIT Madras	IIT Madras	12 Weeks	Rerun	July 22, 2024	October 11, 2024	November 3, 2024	July 29, 2024	August 16, 2024
noc24-cs93	Multi-Core Computer Architecture	Prof. John Jose	IIT Guwahati	IIT Guwahati	12 Weeks	Rerun	July 22, 2024	October 11, 2024	October 26, 2024	July 29, 2024	August 16, 2024
noc24-cs122	C-Based VLSI Design	Prof. Chandan Karfa	IIT Guwahati	IIT Guwahati	12 Weeks	Rerun	July 22, 2024	October 11, 2024	November 3, 2024	July 29, 2024	August 16, 2024
noc24-cs107	Statistical Learning for Reliability Analysis	Prof. Monalisa Sarma	IIT Kharagpur	IIT Kharagpur	12 Weeks	Rerun	July 22, 2024	October 11, 2024	October 27, 2024	July 29, 2024	August 16, 2024
noc24-cs95	Introduction to Industry 4.0 and Industrial Internet of Things	Prof. Sudip Misra	IIT Kharagpur	IIT Kharagpur	12 Weeks	Rerun	July 22, 2024	October 11, 2024	October 26, 2024	July 29, 2024	August 16, 2024
noc24-cs109	Algorithmic Game Theory	Prof. Palash Dey	IIT Kharagpur	IIT Kharagpur	12 Weeks	Rerun	July 22, 2024	October 11, 2024	October 27, 2024	July 29, 2024	August 16, 2024
noc24-cs126	Design & Implementation of Human-Computer Interfaces	Prof. Samit Bhattacharya	IIT Guwahati	IIT Guwahati	12 Weeks	Rerun	July 22, 2024	October 11, 2024	November 2, 2024	July 29, 2024	August 16, 2024
noc24-cs97	Approximation Algorithm	Prof. Palash Dey	IIT Kharagpur	IIT Kharagpur	12 weeks	New	July 22, 2024	October 11, 2024	October 26, 2024	July 29, 2024	August 16, 2024
noc24-cs132	Responsible & Safe AI Systems	Prof. Ponnurangam Kumaraguru Prof. Balaraman Ravindran Prof. Arun Rajkumar	IIIT Hyderabad and IIT Madras	IIT Madras	12 Weeks	New	July 22, 2024	October 11, 2024	November 2, 2024	July 29, 2024	August 16, 2024

5/7/24. 05/07/2024

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Physics
B.Tech. (Engineering Physics)

Sr. No.	Subject	Code	Scheme L-T-P	Credits (Min.)	Notional hours of Learning (Approx.)
	First Semester (1st year of UG)				
1	Waves and Mechanics	EP101	3-1-0	4	70
2	Basics of Electronics	EP103	3-0-2	4	85
3	Thermodynamics	EP105	3-1-0	4	70
4	Numerical Methods and Computer Programming	EP107	3-0-2	4	85
5	Mathematics for Physical Sciences-I	MA123	3-1-0	4	70
6	Indian Value System and Social Consciousness	HS120	2-0-0	2	40
			Total	**22**	**420**
7	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	EPV01 / EPP01	0-0-10	5	200 (20 x 10)
	Second Semester (1st year of UG)				
1	Basics of Electromagnetics	EP102	3-1-0	4	70
2	Introduction to Python Programming	EP104	3-0-2	4	85
3	Quantum Physics and Applications	EP106	3-1-0	4	70
4	Mathematics for Physical Sciences-II	MA118	3-1-0	4	70
5	English and Professional Communication	HS110	3-1-0	4	70
			Total	**20**	**365**
6	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	EPV02 / EPP02	0-0-10	5	200 (20 x 10)
	Third Semester (2nd year of UG)				
1	Solid State Physics	EP201	3-1-0	4	70
2	Classical Mechanics	EP203	3-1-0	4	70
3	Atomic and Molecular Physics	EP231	3-1-0	4	70
3	Elective #1	EP2AA	3-1-0	4	70
4	Energy and Environmental Engineering	EG110	3-0-2	4	85
			Total	**20**	**365**
6	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	EPV03 / EPP03	0-0-10	5	200 (20 x 10)
	Fourth Semester (2nd year of UG)				
1	Introduction to Mathematical Physics	EP202	3-1-0	4	70
2	Semiconductor Physics	EP204	3-0-2	4	85
3	Electrodynamics and its Applications	EP232	3-1-0	4	70
4	Elective #2	EP2BB	3-X-X	4	70/85
5	Artificial Intelligence	CS332	3-0-2	4	85
			Total	**20**	**380/395**
6	Minor / Honor (M/H#1)	EP2CC	3-1-0	4	70
7	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	EPV04 / EPP04	0-0-10	5	200 (20 x 10)

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Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
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	Fifth Semester (3rd year of UG)				
1	Statistical Mechanics	EP301	3-1-0	4	70
2	Introduction to Quantum Computation	EP303	3-1-0	4	70
3	Nuclear and Particle Physics	EP331	3-0-2	4	85
4	Elective #3**	EP3AA	3-1-0	4	70
5	Elective #4 (Specialization#1)	EP3BB / CYXXX	3-X-X	4/5	70/100
			Total	**20/21**	**365/395**
6	Minor / Honor (M/H#2)	EP3CC	3-1-0	4	70
7	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	EPV05 / EPP05	0-0-10	5	200 (20 x 10)
	Sixth Semester (3rd year of UG)				
1	Microprocessor and Microcontrollers	EP302	3-0-2	4	85
2	Plasma Science and Applications	EP304	3-1-0	4	70
3	Digital Electronics	EP332	3-0-2	4	85
4	Machine Learning	EC366	3-0-2	4	85
5	Elective #5**	EP3CC	3-1-0	4	70
6	Elective #6 (Specialization#2)	EP3DD	3-X-X	4	70/85
			Total	**24**	**465/480**
7	Minor / Honor (M/H#3)	EP3EE	3-1-0	4	70
8	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	EPV06 / EPP06	0-0-10	5	200 (20 x 10)
	Seventh Semester (4th year of UG)				
1	Optics, Laser and Photonics	EP401	3-0-2	4	85
2	Elective #7	EP4AA	3-1-0	4	70
3	Elective #8	EP4BB	3-X-X	4	70/85
4	Elective #9 (Specialization#3)	EP4CC	3-1-0	4	70
5	Elective #10 (Specialization#4)	EP4DD	3-1-0	4	70
			Total	**20**	**365/380**
6	Minor / Honor (M/H#4)	EP4EE	3-1-0	4	70
7	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	EPV07 / EPP07	0-0-10	5	200 (20 x 10)
	Eighth Semester (4th year of UG)				
1	Industrial Internship / Professional Experience (Mandatory)	EP402	0-0-40	20	800 (20 x 40)
			Total	**20**	**800**

**NPTEL, SWAYAM and other Massive Open Online Course (MOOC) approved by DAAC

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Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
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Sr. No.	Optional Core	Code	Scheme L-T-P
1.	Atomic and Molecular Physics	EP231	3-1-0
2.	Electrodynamics and its Applications	EP232	3-1-0
3.	Nuclear and Particle Physics	EP331	3-0-2
4.	Digital Electronics	EP332	3-1-0

Sr. No.	Electives	Code	Scheme L-T-P
	Elective #1 (3rd semester)		
1	Discrete Mathematical Structure	MA205	3-1-0
2	Professional Ethics, Economics and Business Management	MG210	3-1-0
	Elective #2 (4th semester)		
1	Data Structure	CS102	3-0-2
2	Interpretative Molecular Spectroscopy	CY302	3-1-0
	Elective #3 (5th semester)		
1	Introduction to Special Theory of Relativity	EP351	3-1-0
2	Basics of Astronomy and Astrophysics	EP353	3-1-0
3	Advanced Quantum Mechanics	EP355	3-1-0
	Elective #4 (5th semester)		
4	Remote sensing	EP357	3-1-0
5	Low-Dimensional Physics and Applications	EP359	3-1-0
6	State and Properties of Matter	CY205	3-1-2
	Elective #5 (6th semester)		
1	Materials Science and Engineering	EP352	3-1-0
2	Density Functional Theory and Applications	EP354	3-1-0
3	Particle Physics and Applications	EP356	3-1-0
4	Nuclear Science and Technology	EP358	3-0-2
	Elective #6 (6th semester)		
5	Solar Cell Technology	EP360	3-1-0
6	Non-Destructive Testing	EP362	3-1-0
7	Thin Films and Vacuum Technology	EP364	3-1-0
8	Global Navigation Satellite System	EP366	3-1-0
	Elective #7 (7th semester)		
1	Astrophysics and Space Science	EP451	3-1-0
2	Introduction to Quantum Field Theory	EP453	3-1-0
3	Advanced Quantum Computation	EP455	3-1-0
	Elective #8 (7th semester)		
4	Electromagnetic Communication	EP457	3-1-0
5	Characterization Techniques	EP459	3-0-2
6	Elementary Excitation in Solids	EP461	3-1-0

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	Elective #9 (7th semester)		
7	Condensed Matter Physics	EP463	3-1-0
8	Microwave Plasma Technology	EP465	3-1-0
	Elective #10 (7th semester)		
9	Nanoscience and Nanotechnology	EP467	3-1-0
10	Laser Technology and Applications	EP469	3-1-0
11	General Theory of Relativity	EP471	3-1-0

Sr. No.	**B. Tech. (AI, CE, ChE, CSE, ECE, EE, ME) (Minor in Engineering Physics)**	**Code**	**Scheme L-T-P**
1.	Quantum Physics and Applications	EP106	3-1-0
2.	Solid State Physics	EP201	3-1-0
3.	Electrodynamics and its Applications	EP232	3-1-0
4.	Atomic and Molecular Physics	EP231	3-1-0

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Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
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B.Tech. (Engineering Physics)

First Year of Four Years of B.Tech. (Engineering Physics) B.Tech. I, Semester-I WAVES AND MECHANICS EP 101	Scheme	L	T	P	Credit
		3	1	0	4

1.	**Course Outcomes (COs):** **At the end of the semester students will be able to**
CO1	Provide a basic understanding of vector algebra and coordinate systems.
CO2	Define the concepts of various laws of motion and moments of inertia.
CO3	Explain Euler's concepts related to rigid body motion.
CO4	Interpret the elastic properties of materials and rephrase the concept of hydrodynamics.
CO5	Develop an understanding of simple harmonic motions via various applications.
CO6	Classify waves and oscillations.

2.	**Syllabus**	
	FUNDAMENTALS OF VECTOR ALGEBRA AND DIFFERENT COORDINATE SYSTEMS	**(07 Hours)**
	Unit vectors, Vector operations, Scalar and vector triple products, Vector algebra in terms of the components, Differential calculus, Cartesian coordinate system, Cylindrical coordinate system, Spherical coordinate system.	
	NEWTON'S LAWS OF MOTION, CONSERVATION LAWS, AND MOMENTS OF INERTIA	**(08 Hours)**
	Mechanics of single and many particles, Equation of motion, Various conservation laws, Moments of inertia, Motion in the central force field	
	RIGID BODY MOTION	**(08 Hours)**
	Euler's theorem, Angular momentum and kinetic energy, Euler's equation of motion, Euler's angles.	
	ELASTICITY AND HYDRODYNAMICS	**(08 Hours)**
	Stress and strain, Young's modulus, Shear modulus and Bulk modulus, Buoyancy, Types of fluid flow, Bernoulli's equation, Viscosity, Terminal velocity.	
	WAVES	**(07 Hours)**
	Wave Motion, Interference and the principle of superposition, Reflection and transmission of waves,Standing waves, Vibration, Transverse and longitudinal waves; Propagation of sound wave, its properties, Beats, Diffraction, Doppler effect.	
	OSCILLATIONS	**(07Hours)**
	Simple Harmonic Oscillations, Damped Oscillations, Coupled Oscillations, and Resonance.	
	Tutorials will be based on the coverage of the above topics separately (15 Hours)	
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

3.	**Tutorials**
1.	Proof of various relations formed using the different kind of vectors.
2.	Cover the various mechanical and electrical problems based on vector analysis.
3.	Though the numerical exercise one will learn the role of coordinate systems to solve the problems.
4.	Problems based on the motion of a single and many particles under the influence of different kindof forces.
5.	Projectile motion of particle, Motion of a charged particle in electromagnetic fields, Variousproblems related to moment of inertia.
6.	Numerical questions based on the aspects covered in the section of rigid body motion.
7.	Various types of questions for the calculation of stress, strain, young's modulus, shear modulus and bulk modulus;
8.	Numerical problems based on Bernoulli principles and terminal velocity.
9.	Basic numerical questions to understand the concept of waves on string and sound waves both andobtain various physical parameters used to quantify the waves.
10.	Problems based on simple harmonic motion, damped and coupled oscillations etc.

4.	**BOOKS RECOMMENDED**
1.	Mathur D. S., Mechanics, S. Chand & Company, 2022.
2.	Takwale R. G. & Puranik P. S., Introduction to Classical Mechanics, Tata McGraw-Hill Book Co., 2018.
3.	Feynman R. P., Lighton R. B. and Sands M., The Feynman Lectures in Physics Vol. 1, NarosaPublishers, 2021.
4.	Verma H. C., Concepts of Physics, Vol. 1 & 2, Bharati Bhavan, 2020.
5.	Landau L. D. & Lifshitz E M, Course on Theoretical Physics, Vol. 1: Mechanics, Addison- Wesley, 2012.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Physics
B.Tech. (Engineering Physics)

First Year of Four Years of B.Tech. (Engineering Physics) B.Tech. I, Semester-I BASICS OF ELECTRONICS EP 103	Scheme	L	T	P	Credit
		3	0	2	4

1.	Course Outcomes (COs): At the end of the semester students will be able to
CO1	Understand the basis concept of circuit analysis theorem
CO2	Demonstrate familiarity with basic electronic components and use them to design simple electronic circuits
CO3	Describe the application of transistors for Current and voltage amplification. Also, to describe the characteristics of different configurations of the transistor
CO4	Discuss the ideal of operational amplifier and their electrical parameters
CO5	Analyze and design the different types of Oscillators, and their applications

2.	Syllabus	
	BASIC CIRCUIT ANALYSIS	**(06 Hours)**
	Kirchhoff's current and voltage law, Network analysis, Superposition theorems.	
	SEMICONDUCTOR JUNCTION DIODES & APPLICATIONS	**(08 Hours)**
	The open circuit p-n junction, Energy bands in junction diode, I-V characteristics of p-n junction,diode as rectifier, Half-wave, full-wave, and bridge rectifier. Various applications of diode	
	SEMICONDUCTOR TRANSISTOR & APPLICATIONS	**(08 Hours)**
	Junction transistor, transistor construction, CB, CE and CC configurations, cut-off and saturation regions, transistor load-line, Quiescent point, Transistor as an amplifier, Current gain and voltagegain.	
	FREQUENCY RESPONSE OF AMPLIFIERS	**(07 Hours)**
	The gain-bandwidth product, frequency response of CB, CE and CC amplifier, Classification of amplifiers, Feed-back in amplifiers and its classification, Study of different properties with feed- back Amplifier applications.	
	OPERATIONAL AMPLIFIERS	**(08 Hours)**
	The differential amplifier, The basic operational amplifier, The emitter-coupled differential amplifier, Transfer characteristics of a differential amplifier, Offset error voltage and currents, Parameters, Frequency response.	
	OSCILLATORS	**(08 Hours)**
	Criteria for oscillation, tank circuit, L-C oscillator, Hertley Oscillator, Colpitts oscillator, The phaseshift oscillator, the Wien bridge oscillator, Crystal oscillator.	
Tutorials will be based on the coverage of the above topics separately (15 Hours)		
(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)		

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3.	**Practicals**
1.	Study and verification of Norton's Theorem.
2.	Study and verification of Thevenin's Theorem.
3.	Study and verification of Reciprocity Theorem.
4.	Study and verification of Superposition Theorem.
5.	Study and verification of Maximum Power Theorem.
6.	Study of Half Wave Rectifier.
7.	Study of Full Wave Rectifier.
8.	Study of Full Wave Bridge Rectifier.

4.	**Books Recommended**
1.	Ryder, J.D., Electronics fundamentals and applications: Integrated and Discrete Systems, Prentice – Hall of India, 2012.
2.	Sze, S.M., Physics of Semiconductor Devices, John Wiley & sons, 2018.
3.	Floyd, T.L., Electronic Devices (5th ed). Pearson education Asia, 2018.
4.	Malvino, A.P. Electronic Principles, Tata McGraw Hill, 2014.
5.	Mottershed, A., Electronic Devices and circuits, Prentice Hall India, 2017.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
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B.Tech. (Engineering Physics)

First Year of Four Years of B. Tech. (Engineering Physics) B. Tech. - I, Semester - I THERMODYNAMICS EP105	Scheme	L	T	P	Credit
		3	1	0	4

1.	**Course Outcomes (COs):** **At the end of the course, the students will be able to**
CO1	Explain the fundamental concepts of thermodynamics laws and thermodynamic processes
CO2	Acquire the knowledge of Maxwell's thermodynamics relations and thermodynamic potentials.
CO3	Learn the concepts of black body radiation from thermodynamics point of view.
CO4	Develop the fundamental concept of kinetic theory of gases.
CO5	Learn the properties of ideal gas and real Van der wall's gas state.

2.	**Syllabus**	
	FUNDAMENTALS OF THERMODYNAMICS	**(10 Hours)**
	Zeroth law of Thermodynamics, First and Second laws of Thermodynamics, Work done in different Thermodynamic process, Heat capacity and Specific heat capacity, Internal energy and entropy, Heat engine, Carnot Cycle and Theorem, Calculations of change of internal energy and entropy in various thermodynamic processes.	
	THERMODYNAMICS POTENTIALS & MAXWELL'S RELATIONS	**(08 Hours)**
	Internal Energy, Gibbs and Helmholtz energy, Gibb's paradox and its resolution, Enthalpy, Maxwell's thermodynamic relations, Application of Maxwell's thermodynamic relations.	
	THERMODYNAMICS OF BLACK BODY	**(06 Hours)**
	Black body and characteristics, Radiation principles like Rayleigh Jeans, Wein's and Planck's law of black body radiation	
	KINETIC THEORY OF GASES	**(07 Hours)**
	Maxwell Boltzmann equation, Postulates of kinetic theory of gases, velocity of gas molecules, Molecular energy, Kinetic-molecular model of an ideal-gas, kinetic interpretation of temperature, Degree of freedom of gas molecules, Maxwell's law of equipartition of energy.	
	TRANSPORT PROPERTIES	**(07 Hours)**
	Viscosity of a gas, Thermal conductivity of gases, Van der wall's equation of state, Brownian motion.	
	BASICS OF STATISTICAL PHYSICS	**(07 Hours)**
	Concept of microstate and macro-state, Phase space, Principle of equal a priori probabilities, Thermodynamic probability, Fermi Dirac, Maxwell Boltzmann and Bose Einstein distributions.	
	Tutorials will be based on the coverage of the above topics separately.	**(15 Hours)**
		(Total Contact Time: 45 Hours + 15 Hours= 60 Hours)

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

3.	**Tutorials**
1	Cover a variety of numerical problems to understand the concepts of thermodynamics.
2	Problems based on refrigerator, heat engine and Carnot engine to understand its working principle.
3	Calculation of various equilibrium quantities such as heat capacity, internal energy, pressure, volume, temperature etc. using the thermodynamics potential and Maxwell's relations.
4	Numerical exercise on Maxwell Boltzmann equation and distribution function to understand its concepts used in Kinetic Theory of gases.
5	Problems to obtain the various equilibrium quantities derived in the section of kinetic theory of gases.
6	Problems based on transport properties of gases mainly focused on the calculation of viscosity and thermal conductivity.
7	Problems based on radiation principles, Wein's and Planck's law related to the thermodynamics of black body radiation.
8	Basic problems to get idea about the various terminology used in statistical physics for example, microstate, macro state, configuration space, phase space, probabilities.
9	Problems based on Fermi Dirac, Maxwell Boltzman and Bose Einstein distributions.

4.	**Books Recommended**
1	Sears F. W. & Salingar, Thermodynamics, Kinetic theory and Statical Thermodynamics, 3rdEdition. Addison-Wesley/Pearson, 2023.
2	Young & Freedman, Sears and Zemanski's University Physics, Pearson Education, Singapore, 2022.
3	Feynman R. P., Leighton R. B. and Sands M., The Feynman Lectures in Physics, Vol.1 Narosa Publishers, 2018.
4	Zemanski M. W., Heat and Thermodynamics, McGraw Hill, 2022.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Physics
B.Tech. (Engineering Physics)

First Year of Four Years of B. Tech. (Engineering Physics) B. Tech. - I, Semester - I NUMERICAL METHODS AND COMPUTER PROGRAMMING EP107	Scheme	L	T	P	Credit
		3	0	2	4

1.	Course Outcomes (COs): At the end of the semester students will be able to
CO 1	Students will be able to understand basics about error and numerical solution method for solving Algebraic and Transcendental Equations
CO 2	Analyze about interpolation and curve fitting method for solve real world problems
CO 3	Understand about method for Numerical integration and Ordinary Differential Equations
CO 4	Understand of basics of computers and programming language
CO 5	students will be able to simulate that physical science problems by knowing some compiler languages

2.	Syllabus	
	BASICS OF COMPUTER PROGRAMMING	**(10 Hours)**
	Operating systems, higher level compiler languages, algorithm; flow charting, C Language: Introduction to C language, identifiers and keywords, data types, constants and variables, arithmeticexpressions; input and output statements, conditional statements: while-loop, for-loop, do while– loop; arrays; logical operators and expressions, structures: switch, break and continue statements.	
	C PROGRAMMING	**(06 Hours)**
	C Language: functions; structures; pointer data type; random and sequential files, file handling in C.	
	NUMERICAL METHOD FOR FINDING ROOTS OF EQUATION	**(06 Hours)**
	Error in Numerical Calculation, Errors and their computations, Absolute, relative and percentageerrors, general error formula Solutions of Algebraic and Transcendental Equations, Bi-Section Method, Graphical Method, Regular False, Newton Raphson Method.	
	NUMERICAL INTERPOLATION AND POLYNOMIAL CURVE FITTING	**(07 Hours)**
	Interpolation, Finite Difference, Forward difference, backward difference, Central Difference, Newton interpolation formula, Lagrange interpolation formula, Least Square Fitting Method & Curve Fitting by polynomials.	
	NUMERICAL METHOD FOR INTEGRATION AND ORDINARY DIFFERENTIAL EQUATIONS	**(08 Hours)**
	Numerical Integration, Newton-Cote's formula, Trapezoidal, Simpson 1/3rd and 3/8th rule and Weddle rules.	

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	Numerical Solutions of Ordinary Differential Equations: Euler, Picard and Taylor series methods,Runge–Kutta 2nd order and 4th order method.	
	C PROGRAMMING PRACTICE	**(08 Hours)**
	C Programs: Program writing in C for interpolation, integration, roots of equations, matrixdiagonalization, solution of differential equations. Good programming practices.	
	Practical will be based on the coverage of the above topics separately	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

3.	**Practicals**
1	Error in numerical computation, error in construction of a model, approximations, Truncationerror and their estimation
2	Solutions of Algebraic and Transcendental Equations using Newton Raphson method.
3	Interpolation using Lagrange's formula.
4	Linear square fitting and Curve fitting by polynomials method.
5	Numerical Integration using Simpson 1/3rd method.
6	Numerical Solutions of Ordinary Differential Equations using Runge–Kutta Method.
7	Writing and testing C program for Error calculation.
8	Writing and testing C program for Newton Raphson method.
9	Writing and testing C program for Lagrange's formula.
10	Writing and testing C program for Curve fitting.
11	Writing and testing C program for Simpson 1/3rd method.
12	Writing and testing C program for Runge–Kutta Method.

4.	**Books Recommended**
1	Chapra S. C. and Canale R. P., Numerical Methods for Engineers. 7th Edition, TataMcGraw Hill, 2021.
2	Sastry S. S., Introductory Methods of Numerical Analysis, 2nd Edition, PHI, 2022.
3	Hoffman J. D., Numerical Methods for Engineers and Scientist, 2nd Edition, CRC Press, 2018.
4	Xavier C., C Language and Numerical Methods, 2nd Edition, New Age publishers, 2024.
5	Herbert Scheldt, C: The Complete Reference, 4th Edition, McGraw Hill Education, 2018.

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Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Physics
B.Tech. (Engineering Physics)

First Year of Four Years of B. Tech. (Engineering Physics) B. Tech. - I, Semester - I MATHEMATICS FOR PHYSICAL SCIENCES-I MA123	Scheme	L	T	P	Credit
		3	1	0	4

1.	Course Outcomes (COs): At the end of the semester students will be able to
CO1	Explain the basic concept of ordinary differential equation with its different forms and methods.
CO2	Discuss the related Applications in Mathematical Modelling and with knowledge of Ordinarydifferential equations, can resolved here.
CO3	Narrate about the series solution and Frobenius series solution with different point.
CO4	Illustrate the PDE with linear and Non-linear equations and its solution.
CO5	Discuss the Vector calculus and System of Linear Algebraic equations.

2.	Syllabus	
	ORDINARY DIFFERENTIAL EQUATION	**(10Hours)**
	Reorientation of differential equation first order first degree, exact differential equation and Integrating factors, first order higher degree odes, solvable for p, y and x, Solution of homogenous equations higher order, complementary functions, Particular Integrals, Linear differential equation with variable coefficient, Cauchy's Euler and Legendre's equation with variable coefficient, Method of variation of parameters.	
	APPLICATION OF DIFFERENTIAL EQUATION (MATHEMATICAL MODELLING)	**(07 Hours)**
	Modeling of Real world problems particularly Engineering System, Electrical network models (LCR),spread of epidemic (SI, SIS, SIR), Newton's Law of cooling. Single compartment modelling, Bending of beam models.	
	SERIES SOLUTION AND SPECIAL FUNCTIONS	**(07 Hours)**
	Regular point, Singular point, series solution of ODE of 2nd order with variable coefficient with special emphasis to differential equation of Legendre's and Bessel's for different cases of roots of indicial equations.	
	INRODUCTION TO PARTIAL DIFFERENTIAL EQUATION	**(08 Hours)**
	Introduction to Partial differential equation, Formation of partial differential Equation, Partial differential Equation of first order, Linear partial differential equation of first order (Pp+Qq-R) and method of obtaining its general solution, Non-linear partial differential equation of first order f(p, q)=0, f(z.,p.,q)=0, f(x, p)=g(y,q), z=px + qy +f(p,q).	
	VECTOR CALCULUS	**(07 Hours)**
	Scalar and vector point function, differential operator, gradient, directional derivative, divergence, curl and Laplacian operator with their properties, Line integral, Surface Integral, Volume integral, Green's, Gauss and Stokes theorem (Only statement) & application.	

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

	SYSTEM OF LINEAR ALGEBRIC EQUATION	**(06 Hours)**
	Linear systems, Elementary row and column transformation, rank of matrix, consistency of linear system of equations, Linear Independence and Dependence of vectors, Gauss Elimination method, Gauss-Jorden Method, Gauss-Jacobi Iteration Method	
	Tutorials will be based on the coverage of the above topics separately.	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3.	**Tutorials**
1	Tutorial one will be related to Ordinary differential equations.
2	Tutorial two, also will be on ordinary differential equations with variable co-efficient.
3	Tutorial three will be on different examples of ordinary differential equations.
4	Tutorial four will be on Mathematical modelling.
5	Tutorial five will be on Series solution and other special cases of it.
6	Tutorial six will cover partial differential equations.
7	Tutorial seven will be on examples of partial differential equations.
8	Tutorial eight will be on Vector Calculus.
9	Tutorial nine will be on applications of Area, Volume.
10	Tutorial ten will be on system of linear algebraic equations

4.	**Books Recommended**
1	Kreyszing E., Advanced Engineering Mathematics, John Wiley & Sons, Singapore, Int Student Ed. 2015.
2	James Steward De, Calculus, Thomson Asia, Singapore, 2003.
3	O'Neel Peter., Advanced Engg. Mathematics, Thompson, Singapore, Ind. Ed. 2002.
4	Hilderband, F. B., Methods of Applied mathematics, PHI, New Delhi, 1968
5	Wiley C. R., Advanced Engineering Mathematics, McGraw Hill Inc., New York Ed. 1993,
	Reference Books
1	Ramana D. V., Higher Engg. Mathematics, The MaGraw-Hill Inc., New Delhi, 2007.
2	Hay George E., Vector and Tensor Analysis. Dover Publications, 2012.
3	Srimanta Pal, Subodh C. Bhunia, Engineering Mathematics, Oxford University Press, New Delhi, 2015.
4	Boas.Mary L., Mathematical Methods in the Physical Sciences, John Wiley & Sons,Ed.2005.
5	Kapur. J. N., Mathematical Models in Biology and Medicine. East west Press, New Delhi 1985.

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Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Physics
B.Tech. (Engineering Physics)

First Year of Four Years of B. Tech. (Engineering Physics) B.Tech. I /M.Sc. I: Semester I/ II INDIAN VALUE SYSTEM AND SOCIAL CONSCIOUSNESS HS120	Scheme	L	T	P	Credit
		2	0	0	2

1.	Course Outcomes (COs): At the end of the course, the students will be able to
CO1	interpret the important values that need to be cultivated
CO2	analyse the cultures depicted in Ramayana, Mahabharata, Jainism and Buddhism
CO3	review the structure of Indian knowledge system
CO4	discuss the significance of constitution of India
CO5	demonstrate social responsibility

2.	Syllabus	
	HUMAN VALUES AND CONSCIOUSNESS	**(08 Hours)**
	Human Values Definition and Classification of Values; The Problem of Hierarchy of Values andtheir Choice; Self-Exploration; 'Basic Human Aspirations; Right understanding, Relationship and Physical Facility; fulfilment of aspirations; Understanding Happiness and Prosperity, Harmony at various levels. What Is Consciousness? ; Can We Build A Conscious Machine?; Levels Of Consciousness; Mind,Matter And Beyond; Holistic Lifestyle; Dealing With Anxiety; Connecting Mind To Brain; Minds, Brains, And Programs.	
	INDIAN CULTURE AND HERITAGE	**(07 Hours)**
	Culture and its salient features: The Vedic – Upanishadic Culture and society, Human aspirations in those societies; Culture in Ramayana and Mahabharata: The Ideal Man and Woman, Concepts Maitri, Karuna, Seela, Vinaya, Kshama, Santi, Anuraga – as exemplified in the stories and anecdotes of the Epics; The Culture of Jainism: Jaina conception of Soul, Karmaand liberation, Buddhism as a Humanistic culture; The four Noble truths of Buddhism; Vedanta and Indian Culture;	
	INDIAN KNOWLEDGE SYSTEM	**(08 Hours)**
	Indian knowledge as a unique system, Place of Indian knowledge in mankind's evolution, Relevance of Indian knowledge to present day and future of mankind, Nature of Indian Knowledge; Structure of Indian Knowledge: Types of knowledge (para, apara), The scientific and the unscientific, Instruments for gaining and verifying knowledge, Knowledge traditions: Lineages, Instruments - debate, epistemology and pedagogy, The inverted tree – axiomatic, deductive, empirical knowledge, and evolution of knowledge; Disciplines of Study: A brief outline of	

	the subjects, the major contributions and theories along with timelines where relevant: Mathematics; Astronomy; Physical Sciences; Cosmogony; Language studies;Astrology; Moral studies/righteousness; Statecraft and political philosophy	
	INDIAN CONSTITUTION	**(04 hours)**
	History of Making of the Indian Constitution; Philosophy of the Indian Constitution: Preamble; Salient Features; Contours of Constitutional Rights & Duties; Organs of Governance: Parliament; Composition; Qualifications and Disqualifications; Powers and Functions	
	SOCIAL RESPONSIBILITY	**(03 Hours)**
	Social Responsibility: Meaning and Importance, Different Approaches of Social Responsibility. Social Responsibility of Business towards different Stakeholders. Evolution and Legislation ofCSR in India.	
	(Total Contact Time: 30 Hours)	

3.	**Books Recommended**
1	D. K. Chaturvedi, Professional Ethics Values and Consciousness, Ane Books Pvt. Ltd., 2023.
2	R.R. Gaur, R Sangal, G. P. Bagaria, Human Values and Professional Ethics, Excel Books, New Delhi, 2010.
3	A.N. Tripathi, Human Values, New Age Intl. Publishers, New Delhi, 2004.
4	P R Rao, Indian Heritage and Culture, Sterling Publishers Pvt. Ltd, 1988.
5	D. Singh, Indian Heritage and Culture, APH Publishing Corporation, 1998.
6	Sri Prashant Pole, Treasure Trove of Indian knowledge, Prabhat Prakashan, 2021.
7	Sri Suresh Soni, Sources of our cultural heritage, Prabhat Prakashan, 2018.
8	D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Physics
B.Tech. (Engineering Physics)

First Year of Four Years of B. Tech. (Engineering Physics) B. Tech. - I, Semester - II BASICS OF ELECTROMAGNETICS EP102	Scheme	L	T	P	Credit
		3	1	0	4

1.	**Course Outcomes:** **At the end of the semester students will be able to**
CO1	Outline briefly the basics of vector algebra, various coordinate systems and differential calculus.
CO2	Explain the Coulomb's law and Gauss's law and their applications in electrostatics.
CO3	Classify the electric fields in conductors and dielectrics and extend it to understand the polarization effects and apply to boundary value problems.
CO4	Explain the Ampere's law and related aspects, and their applications in magnetostatics.
CO5	Explain the magnetic fields in matter and examine magnetization in linear and nonlinear media.

2.	**Syllabus**	
	VECTOR CALCULUS	**(06 Hours)**
	Vector Algebra, Coordinate Systems and Transformations, Differential Length, Differential Area and Differential Volume; Line, Surface and Volume Integrals, Gradient, Divergence, Curl and Laplacian (Cartesian & Polar Coordinates)	
	ELECTROSTATICS	**(06 Hours)**
	Coulomb's Law, Intensity of Electric field, Gauss's Law and its Application, Divergence and curl of Electric Field, Electric Potential, Work and Energy in Electrostatics.	
	SPECIAL TECHNIQUES	**(08 Hours)**
	Laplace's equation, The method of images, Separation of variables, Multipole expansion	
	ELECTRIC FIELDS IN MATTER	**(08 Hours)**
	Polarization, The Field of a Polarized Object, The electric Displacement, Linear Dielectrics	
	MAGNETOSTATICS	**(08 Hours)**
	The Lorentz Force Law, The Biot-Savart Law, The Divergence and Curl of B, Applications of Ampere's Law, Magnetic Vector Potential	
	MAGNETIC FIELDS IN MATTER	**(08 Hours)**
	Magnetization – Diamagnets, Paramagnets, Ferromagnets, The field of a Magnetized Object, The	

	Auxiliary Field H, Linear and Nonlinear media,	
	Tutorials will be based on the coverage of the above topics separately	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3.	**Tutorials**
1.	Numerical problems based on vector algebra, various coordinate systems and differential calculus.
2.	Problems related to the calculation of electric fields and potentials using coulomb' law and Gauss's law.
3.	Numerical problems based on Laplace's equation, The method of images.
4.	Numerical Problems related to Separation of variables, Multipole expansion.
5.	Problems for the calculation of polarization and fields due to a polarized objects.
6.	Problems related to electric displacement and the calculation of energy and forces in dielectric systems.
7.	Problems based on the Lorentz force law, the Biot-Savart Law and Ampere's law.
8.	Problems based on magnetic vector potentials.
9.	Problems for the calculation of magnetization and the field due to a magnetized object.
10.	Numerical exercise for the calculation of the Auxiliary field H and other problems based on linear and nonlinear media.

4.	**Books Recommended**
1.	Griffiths D. J., Introduction to Electrodynamics, 3rd Edition, Pearson Education, 2022.
2.	Jackson J. D., Classical Electrodynamics, 3rd Edition, Wiley, 2018.
3.	Sadiku M.N.O., Elements of Electromagnetics, 6th Edition, Oxford university press, 2022.
4.	Landau L. D., Lifshitz E. M., The Classical Theory of Fields, Course of Theoretical Physics: Vol. 2, 3rd Edition, Pergamon Press, 2021.
5.	Edminister J. A., Schaum's Outline series, Theory and Problems of Electromagnetics, McGraw Hill, 2023.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Physics
B.Tech. (Engineering Physics)

First Year of Four Years of B.Tech. (Engineering Physics) B.Tech. - I, Semester - II INTRODUCTION TO PYTHON PROGRAMMING EP104	Scheme	L	T	P	Credit
		3	0	2	4

1.	**Course Outcomes (COs):** **At the end of the course, the students will be able to**
CO1	Learn the basics of programming and create your first program in Python IDLE.
CO2	Implement Conditional Statement concepts in your programming.
CO3	Use different Python Libraries and Create an application with the support of graphics in Python.
CO4	Write code using functions, files, and exception handling.
CO5	Implement Python to Physics and Machine Learning problems.

2.	**Syllabus**	
	INTRODUCTION	**(08 Hours)**
	Introduction: The Programming Language, History, features, Debugging: Syntax Errors, Runtime Errors, Semantic Errors, Experimental Debugging, Formal and Natural Languages Features of Python, Python installation and setup, Python IDLE and basic operations, Writing and executing Python programs, Variables and data types, Basic operations, Input/output operations	
	CONDITIONAL STATEMENTS	**(08 Hours)**
	Conditional Statements: if, if-else, nested if–else Looping: for, while, nested loops Control statements: Terminating loops, skipping specific conditions	
	INTRODUCTION TO POPULAR PYTHON LIBRARIES	**(07 Hours)**
	Introduction to popular Python libraries (e.g., NumPy, Pandas, Matplotlib), Introduction to data analysis and visualization in Python, working with data using Python libraries (e.g., Pandas, Matplotlib). GUI Programming With Tkinter, import the module – Tkinter, create the main window (container), add any number of widgets to the main window, and apply the event trigger on the widgets.	
	OVERVIEW OF LISTS, TUPLES AND DICTIONARIES	**(10 Hours)**
	Lists: Values and Accessing Elements, Lists are mutable, traversing a List, Deleting elements from List, Built-in List Operators, Concatenation, Repetition, In Operator, Built-in List functions and methods Tuples and Dictionaries: Tuples, accessing values in Tuples, Tuple Assignment, Tuples as return values, Variable-length argument tuples, Basic tuples operations, Concatenation, Repetition, in Operator, Iteration, Built-in Tuple Functions Creating a Dictionary, Accessing Values in a dictionary, Updating Dictionary, Deleting Elements from Dictionary, Properties of Dictionary keys, Operations in Dictionary, Built-In Dictionary Functions, Built-in Dictionary Methods.	

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

	FILE HANDLING and INTRODUCTION TO ML & AL	**(12 Hours)**
	Files: Text Files, The File Object Attributes, Directories Exceptions: Built-in Exceptions, Handling Exceptions, Exception with Arguments, User-defined Exceptions. Introduction to machine learning and its applications, Introduction to popular Python libraries for machine learning (e.g., scikit-learn, TensorFlow).	
	Practical will be based on the coverage of the above topics separately.	**(30 Hours)**

(Total Contact Time: 45 Hours + 30 Hours= 75 Hours)

3.	**Practical**
1	Program to calculate the sum and average of a list of numbers using functions.
2	Write a program that prints a giant letter A like the one below. Allow the user to specify how large the letter should be.
3	Program to read data from a CSV file using the Pandas library and perform data analysis.
4	Program to plot & save graph of sine wave and cosine wave using Matplotlib.
5	Program to create a class representing a student and calculate their grades based on specific criteria.
6	Program to calculate the mean, median, and mode of a list of numbers using NumPy and statistics.
7	Program to implement linear regression using the scikit-learn library for a given dataset.
8	Program to calculate the roots of a quadratic equation using the math library.
9	Program to compute the derivative of a given function using symbolic mathematics with SymPy.
10	Program to calculate the eigenvalues and eigenvectors of a matrix using NumPy.

4.	**Books Recommended:**
1	Zhang Y., An Introduction to Python and Computer Programming, Springer Verlag, Singapore, 2021.
2	Langtangen H.P., A Primer on Scientific Programming with Python, Springer, 2022.
3	Ham, D. A., Object-oriented Programming in Python for Mathematicians Paperback, 2023.
4	Johansson R., Numerical Python: Scientific Computing and Data Science Applications with NumPy, SciPy, and Matplotlib, Apress,2019.
5	Fuhrer C., Solem, J.E. and Verdier O., Scientific Computing with Python: High-performance scientific computing with NumPy, SciPy, and Pandas, Packt Publishing Limited, 2021.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Physics
B.Tech. (Engineering Physics)

First Year of Four Years of B.Tech. (Engineering Physics) B.Tech. - I, Semester - II QUANTUM PHYSICS AND APPLICATIONS EP106	Scheme	L	T	P	Credit
		3	1	0	4

1.	**Course Outcomes: At the end of the semester students will be able to**
CO1	Remembering the origin of quantum theory and interpret the wave function properties
CO2	Explain the central potential and utilize it to describe the energy spectrum of hydrogen atom
CO3	Identify symmetries in quantum mechanics and interpret the angular momentum and spin in general
CO4	Apply the Schrödinger's time-independent equation in solving various quantum models, and many-body problems.
CO5	Interpret various technological applications of quantum mechanics.

2.	**Syllabus:**	
	ORIGINS OF QUANTUM THEORY & APPLICATIONS	**(12 Hours)**
	The conceptual aspect, The state vectors, Bra-Ket notation, Hilbert space, Operators, Eigenfunctions, Eigenvalues, Commutation relations, Fourier transform, Kronecker and Dirac delta functions, Interpretation of the wave function, The postulates of quantum mechanics.	
	SCHRÖDINGER EQUATION AND RELATED PROBLEMS	**(10 Hours)**
	Equation of motion, Hamiltonian, Time dependent and time-independent Schrödinger equations, Infinite Potential Box, Potential well, Simple Harmonic Oscillator (SHO), etc.	
	CENTRAL POTENTIALS, ANGULAR MOMENTUM AND RADIAL SCHRÖDINGER EQUATION	**(12 Hours)**
	Spherically symmetric potentials, Angular momentum and its components in Spherical coordinate system, Eigenvalues of angular momentum, Spherical harmonics, Atomic orbitals, Reduced Radial Schrödinger Equation, Effective potential.	
	HYDROGEN ATOM PROBLEM	**(05 Hours)**
	The two-body problem, Solution of Hydrogen atom problem, Energy spectrum of Hydrogen atom.	
	TECHNOLOGY APPLICATIONS	**(06 Hours)**
	Tunnel Diode, Scanning Tunnel Microscope (STM), Magnetic Resonance Imaging (MRI), Quantum Computations with Qubits.	
	Tutorials will be based on the coverage of the above topics separately	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

3.	**Tutorials:**
1.	Numerical exercise on various pre-quantum principles and quantum postulates.
2.	Problems related to Bra-Ket algebra, Eigenstates and eigenvalues and Operators.
3.	Problems related to Commutation relations and Fourier transform.
4.	Problems related to Kronecker and Dirac delta functions.
5.	Numerical exercise on the applications of various quantum models.
6.	Problems based on the angular momentum operators.
7.	Problems based on radial Schrödinger equation, effective potential, etc.
8.	Numerical exercise related to Hydrogen atom problem and applications.

4.	**BOOKS RECOMMENDED:**
1.	L. I. Schiff, Quantum Mechanics, McGraw Hill Education, 4th Edition, 2017.
2.	A. K. Ghatak and S. Loknathan, Quantum Mechanics: Theory and Applications, Laxmi Publications, 2022.
3.	Zettili N., Quantum Mechanics: Concepts and Applications; Wiley; 3rd Edition, 2022.
4.	Bransden, B. H. and Joachain, C. J., Quantum Mechanics, Pearson Education; 2nd Edition, 2024.
5.	Mathews, P.M. and Venkateshan, K., A Text book of Quantum Mechanics; McGraw Hill Education, 2nd Edition, 2017.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Physics
B.Tech. (Engineering Physics)

First Year of Four Years of B.Tech. (Engineering Physics) B.Tech. - I, Semester – II MATHEMATICS FOR PHYSICAL SCIENCES -II MA118	Scheme	L	T	P	Credit
		3	1	0	4

1.	Course Outcomes (COs): At the end of the semester students will be able to
CO1	Explain about infinite series.
CO2	Discuss the Fourier series and periodic functions and with different period.
CO3	Narrate the Fourier transform and theorems.
CO4	Explain Complex Variables.
CO5	Illustrate basic of statistics and sampling theory and estimation.

2.	Syllabus	
	INFINITE SERIES	**(05 Hours)**
	Introduction, Positive term series, Comparison test, Cauchy's root test, D'Alembert's test, Raabe'stest, Logarithmic test, Integral test, Gauss's test.	
	FOURIER SERIES	**(07 Hours)**
	Definition, Fourier series with arbitrary period, in particular periodic function with period 2 π. Fourier series of even and odd function, Half range Fourier series.	
	FOURIER TRANSFORM AND FOURIER TRANSFORM OF AN INTEGRAL	**(07 Hours)**
	Fourier transform and its operational properties, Fourier Integral theorem, Fourier Cosine and solution, transform of derivatives, Inversion formula for Fourier transforms.	
	COMPLEX VARIABLES	**(06 Hours)**
	Basic mathematical concept, Analytic function, Cauchy – Riemann equations, Harmonic functions, its applications, Linear transformation of complex domain, bilinear transformations, conformal mapping and its application, complex integration over closed contour.	
	BASIC OF STATISTICS AND PROBABILITY DISTRIBUTION	**(06Hours)**
	Reorientation of random experiments, events, probability and its distributions of Binomial &Poisson‟s, their properties and Normal distribution, jointly distributed random variables, expectedvalues, function of random variable moments, moment generating functions.	
	SAMPLING THEORY AND ESTIMATION	**(07 Hours)**
	Some basics of sampling, statistical inference, Random Samples, Sampling distribution, Sample mean, variance and other statistics, point estimate and interval estimate confidence of interval, maximum likehood estimate.	
	TESTING OF HYPOTHESIS	**(07 Hours)**

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	Sampling and Test of significance, Statistical hypothesis and significance, Type I and Type II errors,Test of significance. Level of Significance, single tail and two tail tests hypothesis Chi-square (2 χ) test, student's t Test of significance of the mean of a random sample, t-test for difference of meansof two small samples, Snedecor‟s variance ratio test or F-test and tis applications.	
	Tutorials will be based on the coverage of the above topics separately	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3.	**Tutorials**
1.	Tutorial one will be related to infinite series.
2.	Tutorial two will be on different test of infinite series for its convergence.
3.	Tutorial three, will be on Fourier series.
4.	Tutorial four will be on Fourier transform.
5.	Tutorial five will cover examples of Fourier integral theorem.
6.	Tutorial six will be on Complex variables.
7.	Tutorial seven will cover basic of statistics.
8.	Tutorial eight will be based on Probability Distribution.
9.	Tutorial nine will be based on Sampling theory.
10.	Tutorial ten will be on Estimation: different test and its applications.

4.	**Books Recommended**
1.	Kreyszing E., Advanced Engineering Mathematics, John Wiley & Sons, Singapore, Int. Student Ed. 1995.
2.	Wiley C. R., Advanced Engineering Mathematics, McGraw Hill Inc., New York Ed. 1993
3.	O‟Neil Peter., Advanced Engg. Mathematics, Thompson, Singapore, Ind. Ed. 2002.
4.	Greenbar Michael D., Advanced Engg. Mathematics, Pearson, Singapore, Ind. Ed. 2007.
5.	Ramana D. V., Higher Engg. Mathematics, The MaGraw-Hill Inc., New Delhi, 2007.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Physics
B.Tech. (Engineering Physics)

First Year of Four Years of B.Tech. (Engineering Physics) B.Tech. - I/ M.Sc. - I, Semester – I/II ENGLISH AND PROFESSIONAL COMMUNICATION HS110	Scheme	L	T	P	Credit
		3	1	0	4

1.	**Course Outcomes (COs):** **At the end of the course, the students will be able to**
CO1	show enhanced reception towards the use of English language.
CO2	choose and employ appropriate words for professional communication.
CO3	develop sentences and text in English coherently and formally.
CO4	demonstrate overall improvement in oral communication.
CO5	analyze and infer from written and oral messages.

2.	**Syllabus**	
	COMMUNICATION	**(05 Hours)**
	Introduction to Communication, Different forms of Communication, Barriers to Communicationand some remedies, Non-Verbal Communication – Types, Non-Verbal Communication in Intercultural Context.	
	VOCABULARY AND USAGE OF WORDS	**(05 Hours)**
	Common Errors, Synonyms, Antonyms, Homophones, and Homonyms; One Word Substitution; Misappropriations; Indianisms; Redundant Words.	
	LANGUAGE THROUGH LITERATURE	**(09 Hours)**
	Selected short stories, essays, and poems to discuss nuances of English language.	
	LISTENING AND READING SKILLS	**(06 Hours)**
	Types of listening, Modes of Listening-Active and Passive, Listening and note taking practice, Practice and activities. Reading Comprehension (unseen passage- literary /scientific/technical) Skimming and scanning, fact vs opinion, Comprehension practice	
	SPEAKING SKILLS	**(10 Hours)**
	Effective Speaking, JAM, Presentation Skills- types, preparation and practice. Interviews- types, preparation and mock interview; Group Discussion- types, preparation and practice.	
	WRITING SKILLS	**(10 Hours)**
	Prerequisites of effective writing, Memo-types, Letter Writing- types, Email etiquette and Netiquette, Résumé-types, Report Writing and its types, Editing.	
	Tutorials will be based on the coverage of the above topics separately	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

3.	**Tutorials**
1	Letter and Resume
2	Group Discussion
3	Presentation Skills (Individual)
4	Role Play on Nonverbal communication
5	Group Presentation
6	Debate
7	Body language and intercultural communication
8	Listening Activities
9	Editing
10	Report Writing
11	Mock interviews
12	JAM

4.	**Books Recommended**
1	Kumar, Sanjay and Pushp, Lata. *Communication Skills*, 2nd Edition, OUP, New Delhi, 2015.
2	Raman, Meenakshi & Sharma Sangeeta. *Technical Communication Principles and Practice*, 3rdEdition, OUP, New Delhi, 2015.
3	Raymond V. Lesikar and Marie E Flatley. *Basic Business Communication skills for Empowering theInternet generation.* Tata McGraw Hill publishing company limited. New Delhi 2005.
4	Courtland L. Bovee, John V. Thill, and Mukesh Chaturvedi. “Business Communication Today.” NinthEdition. Pearson, 2009.
5	Mike Markel. “Practical Strategies for Technical Communication,” Bedford/ St. Martin's SecondEdition, 2016
6	Laura J. Gurak and John M. Lannon. “Strategies for Technical Communication in the Workplace,”Pearson, 2013.

Annexure 67.31
of 67th meeting of the IAAC

DEPARTMENT OF PHYSICS

Vocational Training/ Professional Experience
(Mandatory for Exit and Optional for Others)

VOCATIONAL TRAINING (SEMESTER II)

LINUX AND SHELL PROGRAMMING
PHV02 **Contact Hours: 200**

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Provide a basic understanding on Linux and explain its usages.
CO2	Demonstrate the basic set of commands and utilities in Linux systems.
CO3	Apply basic commands to manipulate data.

2. Course Contents:

- Introduction to the Linux Operating System **(20 Hours)**
- Open Source, Linux Origins **(20 Hours)**
- Distributions, Linux Principles **(10 Hours)**
- Linux versus Windows **(15 Hours)**
- Linux installation **(05 Hours)**
- File system of the Linux **(10 Hours)**
- General usage of Linux kernel **(10 Hours)**
- Basic commands in Linux **(15 Hours)**
- Linux users and groups **(15 Hours)**
- Permissions for files, directory and users, searching a file; directory, zipping and unzipping concepts **(20 Hours)**
- Introduction of Bash shell, Bash features, command line, command line expansion and editing, gnome-terminal **(20 Hours)**
- Scripting basics, creating shell scripts, handling Input/ Output **(20 Hours)**
- CONTINIOUS EVAUATION **(20 Hours)**

Conditions:

- Prerequisites: None
- Minimum 05 students to run the program
- Registration fees: Rs. 3000/- per student
- The course is interdisciplinary in nature and students from Physics, Mathematics, Computer Science, Artificial Intelligence, Electrical Engineering, Electronics Engineering and other departments may enroll.

Faculty Members Involved:

- Dr. Yogesh A. Sonvane
- Dr. Debesh R. Roy

DEPARTMENT OF PHYSICS

Vocational Training/ Professional Experience
(Mandatory for Exit and Optional for Others)

VOCATIONAL TRAINING (SEMESTER III)

Solar Panel Assembling, Testing and Installations

PHV03 **Contact Hours: 200**

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Perform testing on the solar panels for I-V Characteristics
CO2	Evaluate the solar panels and their parameters
CO3	Analyse the peripherals requirements for Solar Panel Operations and MPPT

2. Course Contents:

- Energy Crisis and Renewable Energy Scenario **(10 Hours)**
- Introduction to Photovoltaic Effects **(20 Hours)**
- Fundamentals of Semiconductors **(20 Hours)**
- Solar Cell Functioning **(10 Hours)**
- Solar Cell Characteristics and Efficiency **(15 Hours)**
- Understanding Solar Panels and Their Specifications **(20 Hours)**
- Solar Modules and Panels **(10 Hours)**
- Series Connections and Parallel Connections **(10 Hours)**
- Solar Panel Assembling Steps **(10 Hours)**
- Introduction to Solar Cell Wafers Cutting Technologies **(10 Hours)**
- Solar Modules and Panels Testing for QC **(15 Hours)**
- Solar Panels Installation Processes and Important Issues **(15 Hours)**
- Panel Aging and Various Failure Mechanisms **(15 Hours)**
- CONTINIOUS EVAUATION **(20 Hours)**

3. Conditions:

- Prerequisites: None
- Minimum 05 students to run the program
- Registration fees: Rs. 5000/- per student
- The course is interdisciplinary in nature and students from Physics, Mechanical Engineering, Computer Science, Artificial Intelligence, Electrical Engineering, Electronics Engineering and other departments may enroll.

Faculty Members Involved:

- Dr. Vipul Kheraj
- Dr. D. V. Shah

DEPARTMENT OF PHYSICS

Vocational Training/ Professional Experience
(Mandatory for Exit and Optional for Others)

VOCATIONAL TRAINING (SEMESTER IV)

Automation of Scientific Experiments by Virtual Instrumentation using LabVIEW

PHV04 **Contact Hours: 200**

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Make programs in LabVIEW
CO2	Interface and communicate with power source/meters through computers
CO3	Synchronise and automate some basic scientific experiments using LabVIEW

2. Course Contents:

- Introduction to Scientific Experimental Techniques **(10 Hours)**
- Understanding Scientific Data Analysis **(20 Hours)**
- Introduction to Various Transducers used in Typical Experiments **(20 Hours)**
- Introduction to ADC and DAC **(10 Hours)**
- LabVIEW as a Programming Tool **(15 Hours)**
- Various Data Types & Data Transfer Operations in LabVIEW **(10 Hours)**
- Arithmetic and Logical Operation tools in LabVIEW **(10 Hours)**
- Execution Controls in LabVIEW **(10 Hours)**
- File Managements and data storing techniques in LabVIEW **(15 Hours)**
- Data Acquisition Modules in LabVIEW **(15 Hours)**
- Interfacing and Automation of Optical Spectroscopy Experiment **(15 Hours)**
- Interfacing and Automation of Electrical Characterization Experiment **(15 Hours)**
- Interfacing camera and image processing in LabVIEW **(15 Hours)**
- CONTINIOUS EVAUATION **(20 Hours)**

3. Conditions:

- Prerequisites: None
- Minimum 05 students to run the program
- Registration fees: Rs. 5000/- per student
- The course is interdisciplinary in nature and students from Physics, Mechanical Engineering, Computer Science, Artificial Intelligence, Electrical Engineering, Electronics Engineering and other departments may enroll.

Faculty Members Involved:

- Dr. Vipul Kheraj

Annexure 67.35
of 67th meeting of the IAAC

Sardar Vallabhbhai National Institute of Technology, Surat

Proposal

for

Establishing a Language Lab in Department of HSS

**vide Res no.4 of the Senate Meeting held on 20th September 2022*

Index

The Digital Language Lab

A language lab is a dedicated space designed to supercharge your learning of spoken languages. These labs typically boast audio-visual aids like projectors, screens, speakers, and microphones for playing learning materials, practicing pronunciation, and even recording yourself for self-assessment. Computers equipped with language learning software, online resources, and self-assessment tools further support your independent learning journey.

The language lab helps to master areas like spoken English, pronunciation, and accent reduction. Modern language labs also embrace technology integration, offering access to online resources like language learning applications, dictionaries, and online communities to encourage independent practice and exploration beyond the lab environment. Language lab is a valuable resource for students seeking to overcome communication barriers and achieve fluency in a target language. By providing a dedicated learning environment, personalized feedback, and access to the latest technology, language labs empower students on their journey towards confident and effective spoken language skills.

Relevance of a Language Lab in the department

Department of Humanities and Social Sciences offers courses in Language and Writing Skills and certain Foreign language courses. Establishment of a Language lab in the department of Humanities and Social Sciences will enhance the language skills of the students. Skills of language like Reading and writing can be closely monitored in a classroom and can be easily examined in written examinations but primary skills for language i.e. listening and speaking usually goes unmonitored as with the current Student teacher ratio, it is not feasible for a teacher to accurately monitor speech for each and every student, moreover even if we increase the number of teacher, it would be highly difficult to maintain the uniformity in testing the spoken and listening skill. A computer equipped with adequate hardware and software can provide great assistance to monitor, enhance and improve the Speaking and listening skills Language lab will help the the teacher to monitor for every student, so the teacher can identify what are the major issues students are facing while speaking in English or what are the words, grammatical structures or pronunciation that they find difficult to comprehend.

In order to set up a lab we would require facilities including a physical space, large enough that can accommodate 60 students. Approximately 60 desktop computers compatible to run language software and basic I/o devices like headphones, webcam etc. We may require additional projector and a digital whiteboard to explain few related concepts in the lab. In order to run smoothly and deal with the software related malfunction we will require one person who can deal with the hardware and software related issues in the computer, the concerned person will also be looking after the regular updated of the system and maintaining records of the lab. Some network devices may be required with a seamless dedicated internet connection for smooth functioning of the lab. A Network Attached Storage server would also be useful for safely storing data of the students over a long period of time. Additionally we may require a Ethernet switch that can be helpful for networking among lab computers rather than relying on Internet connection speed or cloud servers.

Hardware Requirement

TEACHER PC	**1 Quantity- Approximate ₹ 1,00,000**
Hardware Requirement	
Processor	3 GHz or More faster - multi-core (64-bit)
RAM	16 GB or Above`
Hard Disk	500 GB SSD or above
Network	1 GBPS
AV Device	Headphone With Mic, Web Camera
Software Requirement	
Operating System	Microsoft Windows Server 2019- Standard or above/Ubuntu 18 or above
Web browser	Firefox, Chrome (Latest Versions)

Students PC	**Quantity-60 – 50,000 X 60= ₹ 30,00,000**
Hardware Requirement	
Processor	3 GHz or More faster multi-core (64-bit)
RAM	4 GB or above
Hard Disk	256 GB SSD
Network	1 GBPS
AV Device	Headphone With Mic, Web Camera
Software Requirement	
Operating System	Windows 10 or above/ Ubuntu-16.04 or above
Web browser	Firefox, Chrome (Latest versions)

NAS Server	**Quantity-1 -50,000 X 1= ₹50,000**
No. of Bays	2 or more
RAM	1 GB or above
Hard Disk	4 TB or above
Network	1 GBPS

Software Requirement

We are seeking a comprehensive language learning platform that actively enhances student learning while fostering improved comprehension. The ideal solution should provide detailed student performance reports alongside access to teacher attendance and performance data for transparency and accountability. It should support learning and teaching in any language. The platform's core functionality should encompass core aspects of language acquisition i.e. Listening and Speaking effectively. It should include features for students to compare and evaluate their work with native speakers, repeat lessons in various formats (text, audio, video), and access advanced study materials. Additionally, the platform should facilitate private communication with teachers, encourage collaborative learning through group discussions and debates, and employ a user-friendly, effective methodology. It should also have some direct student monitoring to ensure progress without disruption. The software should enable real-time evaluation of individual student performance, creation and modification of customized e-Lessons in various formats, assignment of lessons to individuals or groups, and automatic recording of student feedback. Such a platform will significantly enhance the language learning experience for students. Based on pilot survey, there are few software availaible for language lab like:

1. Oréll Digital Language Lab (ODLL),
2. English Language Lab by Digital Teacher.
3. Spears Language Lab ,
4. English Wordsworth Language Lab (EWL),
5. Globus Digital Language Lab

Apart from these there are also other companies which offer similar software but their services are not available in India and which are available in India do not offer similar level of functionality. The software procurement process can either be done with the tendering process or through GeM, as per the institute norms. The software for 60 computers may cost approximately 7,00,000 which includes initial setup and training for running the software.

Furniture Requirement

	Particular	Quantity	Approximate Cost
1	Table for Teacher	1	₹ 10,000
2	Chair for Teacher	1	₹ 10,000
3	Table for Lab Technician	1	₹ 5,000
4	Chair for Lab Technician	1	₹ 5,000
5	Computer Table for Students	60	₹ 1,20,000
6	Chair for Students	60	₹ 60,000
		Total	**₹ 2,10,000**

Staff Requirement

Post	Person
Lab Technician	1
Peon	1
Total	2

Conclusion

In order to setup a language lab the proposed budget of **₹42,00,000** may be incurred but it brings substantial benefits to the educational environment. By investing this amount a superior language learning experience can be created. This investment will lead to improved student outcomes, enhanced teacher effectiveness, and overall institutional growth.

Establishing a language lab within the Department of Humanities and Social Sciences specifically catering to engineers holds immense potential. This initiative will equip students with the vital communication skills crucial for success in today's globalized environment. By providing access to cutting-edge technology, high-quality learning materials, and diverse learning methods, the proposed language lab will empower graduates to:

- Enhance their LSRW (Listening, Speaking, Reading, Writing) skills, enabling them to communicate effectively in professional settings.
- Increase their employability and career prospects by opening doors to international collaborations and opportunities.
- Foster greater interdisciplinary understanding by bridging the gap between engineering and the humanities and social sciences.

The establishment of the language lab will significantly enhance the curriculum and teaching facilities of the foreign language courses offered by the department. Should the language lab be established within the stipulated timeframe, the department may consider the creation of a Centre for Languages that may offers courses to candidates outside of SVNIT. This initiative would not only expand the department's outreach activities but also generate substantial revenue. Given that many institutions offering foreign language courses lack a language lab, integrating such a facility into these courses would provide considerable benefits to students.

The proposed language lab represents a strategic investment in the future of our engineering students, empowering them to become well-rounded, globally competent professionals. We strongly believe that this initiative will yield significant dividends for both the department and the university at large.

Annexure 67.36
of 67th meeting of the IAAC

Proposal for the Establishment of a Centre for Rural Technology Development

Overview

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat is strategically located in an area bordered by tribal communities from six districts of Gujarat: Surat, Tapi, Valsad, Navsari, Dangs, and Bharuch. Known for its robust academic programs and dynamic campus environment, SVNIT Surat, as an Institute of National Importance, is not only committed to academic excellence but also to the comprehensive development of society. Recognizing the socio-economic disparities that exist within these tribal communities and the necessity for inclusive growth, it is vital for SVNIT to initiate proactive measures aimed at elevating the living standards of the tribal population in its vicinity. Other Institutes of National Importance, such as IIT Delhi with its Centre for Rural Development and Technology (CRDT) and IIT Bombay with its Centre for Technology Alternatives for Rural Areas (CTARA), have pioneered similar initiatives. These successful examples highlight the need for SVNIT to establish a dedicated Centre for Tribal Development and Technology to fulfill its societal obligations and leverage its academic strengths for the benefit of marginalized communities.

Rationale:

The Department of Humanities and Social Sciences proposes to establish a Centre for Tribal Development and Technology at SVNIT Surat is supported by several compelling reasons. Firstly, it reflects SVNIT's acknowledgment of its socio-academic responsibility towards the surrounding tribal communities, who often face marginalization and limited opportunities. Secondly, it aligns with the institute's mission to use its academic and technical resources for the betterment of society. Thirdly, it draws inspiration from the successful models of community development and technology integration implemented by other Institutes of National Importance, which have demonstrated significant positive impacts on rural and tribal populations. By creating a center dedicated to these goals, SVNIT can address the unique challenges faced by tribal communities through targeted interventions and innovative solutions.

Objectives:

The Centre for Tribal Development and Technology at SVNIT Surat will pursue a comprehensive set of objectives aimed at promoting the holistic development and empowerment of tribal communities. These objectives include:

1. Community Empowerment: Enhancing the skills and capacities of tribal individuals through targeted training programs in agriculture, entrepreneurship, and various vocational disciplines.

2. Technology Adoption: Promoting the use of appropriate technologies to solve local problems, at local level improve livelihoods, and enhance healthcare services.

3. Research and Innovation: Conducting research tailored to the specific needs and challenges of tribal communities, fostering innovation that is both sustainable and culturally sensitive.

4. Collaborative Partnerships: Building and nurturing partnerships with governmental bodies, non-governmental organizations, and other academic institutions to implement collaborative and impactful interventions.

Proposed Activities:

To achieve these objectives, the center may engage in a variety of activities, including but not limited to:

1. Skill Development Workshops: Organizing workshops focused on enhancing skills in agriculture, entrepreneurship, and vocational training to improve employability and economic self-sufficiency.

2. Educational Outreach Programs: Conducting outreach initiatives aimed at promoting higher education among tribal youth, including scholarship programs, preparatory classes for entrance exams, and career counseling.

3. Technology Showcases: Enhancing appropriate local technologies that can improve livelihoods, such as sustainable farming practices, renewable energy solutions, and health care innovations.

4. Research Projects: Initiating and supporting research projects that address specific issues faced by tribal communities, ensuring that these projects are participatory and involve community members as active collaborators.

5. Community Engagement Initiatives: Organizing health camps, awareness campaigns, and other community-centric activities to improve health and well-being and raise awareness about important social issues.

Implementation Plan:

The successful implementation of the Centre for Tribal Development and Technology will require a structured and systematic approach, encompassing several key steps:

1. Formation of a Committee: Establishing a diverse steering committee and an advisory committee comprising representatives from SVNIT. In order to enhance the growth of the centre the committee may invite or include members from academia, government, and experts with significant experience in developing the tribal communities to oversee the planning and implementation process.

2. Resource Mobilization: Securing funding and resources through grants, partnerships with governmental and non-governmental organizations, and corporate social responsibility (CSR) initiatives.

3. Infrastructure Development: Establishing the necessary infrastructure within the SVNIT campus, including dedicated spaces for training, research, and community activities.

4. Staff Recruitment: Recruiting a team of dedicated staff members with expertise in community development, technology adoption, and project management to ensure effective operation of the center.

5. Monitoring and Evaluation: Implementing a robust framework for monitoring and evaluation to track progress, ensure accountability, and measure the impact of the center's activities on the tribal communities.

Conclusion:

The establishment of a Centre for Tribal Development and Technology at SVNIT Surat represents a significant opportunity to address socio-economic disparities and contribute to the holistic development of tribal communities. Through collaborative efforts, innovative interventions, and a steadfast commitment to social responsibility, SVNIT can make a meaningful difference in the lives of the tribal populations it serves. This initiative not only aligns with the institute's mission of academic excellence but also underscores its dedication to societal impact, setting a precedent for other institutions to follow.

Annexure 67.37
of 67th meeting of the IAAC

Sardar Vallbhbhai National Institute of Technology, Surat

NCC As an elective Course

SCHEME OF INSTRUCTION AND SYLLABI

(for all B.Tech/M.Sc students)

(Effective from 2024-25)

SCHEME OF INSTRUCTION

NCC As elective Subject

Special Instructions:

The curriculum is proposed by NCC Group Head Quarters to offer NCC as an Elective course

Eligibility: Age Group : 16-23 Years

Class : First Year of B.Tech. or M.Sc. in any discipline

Height preferable not less than 168 cm

Physical Test standards as below

- 800 Mtr Run
- Push Ups Min 10
- Sit Ups Min 10
- 5 Mtr shuttle 10/min

Written Test of 25 Marks based on General Knowledge, current affairs (From 15 August last year to 14 August Present Year) and About NCC/Army.

Any special talent preferred painting, Poetry, Singing & dancing (only classical), playing a Musical Instrument, dramatics, sports, etc.

Students who fulfil the above criteria must participate in the NCC Enrollment selection procedure.

Starts from First Semester: The NCC starts from I Year, I Sem and is completed by III Year, II Semester

Credits for Practical training: The credit for NCC-Practical is also to be considered equal to that of L (T) because of the intensity of the training in Practical and Camps.

S. No.	Course Code	Name of the Course	L	T	P	Credits	Sem.
1	NCC01	NCC Foundation Course: Part 1	1	1	0	2	I
2	NCC02	NCC Foundation Course: Part 2	1	1	0	2	II
3	NCC03	NCC Intermediate Course: Part 1	1	1	3*	5	III
4	NCC04	NCC Intermediate Course: Part 2	1	1	0	2	IV
5	NCC05	NCC Advance Course: Part 1	1	1	3*	5	V
6	NCC06	NCC Advance Course: Part 2	1	1	0	2	VI
		Total				**18**	

* 3 Credits for summer camps at the end of 2nd and 4th semesters are shown in 3rd and 5th semesters

Annexure 67.38
of 67th meeting of the IAAC

Sardar Vallbhbhai National Institute of Technology, Surat

Community Engagement and Social Responsibility

SCHEME OF INSTRUCTION AND SYLLABI

(for all B.Tech/M.Sc students)

(Effective from 2024-25)

SCHEME OF INSTRUCTION

Community Engagement and Social Responsibility

The curriculum is proposed by (UGC letter No. F9-5/2021(PS/MoE) Dated 17 March 2022 to offer Community Engagement and Social Responsibility as an additional course

S. No.	Course Code	Name of the Course	L	T	P	Credits
1	CESR01	Community Engagement and Social Responsibility: Part 1	0	1	1	2
Total						02

Objectives:

- To develop an appreciation of rural culture, lifestyle and wisdom amongst students.
- To learn about the status of various agricultural and development programmes.
- To understand the causes of distress and poverty faced by vulnerable households and explore solutions for the same.
- To apply classroom knowledge of courses to field realities and thereby improve the quality of learning.

Learning Outcomes

After completing this course, students will be able to

- Gain an understanding of rural life, Indian culture and ethos and social realities
- Develop a sense of empathy and bonds of mutuality with the local community
- Appreciate significant contributions of local communities to Indian society and economy
- Learn to value the local knowledge and wisdom of the community
- Identify opportunities for contributing to community's socio-economic improvements

Credit

Two credits, 30 hours, at least 50% in the field, for all students

Contents

Divided into four Modules, field immersion is part of each Unit

Course Structure: 2 Credits Course (1 Credit for Classroom and Tutorials and 1 Credit for Field Engagement)

1	***Appreciation of Rural Society***	Rural lifestyle, rural society, caste and gender relations, rural values with respect to community, nature and resources, elaboration of "soul of India lies in villages' (Gandhi), rural infrastructure.	Prepare a map (physical, visual or digital) of the village you visited and write an essay about inter-family relations in that village.	– Classroom discussions – Field visit** – Assignment Map	2 4 2
2	***Understanding rural and local economy and livelihood***	Agriculture, farming, land ownership, water management, animal husbandry, non-farm livelihoods and artisans, rural entrepreneurs, rural markets, migrant labour.	Describe your analysis of the rural house hold economy, its challenges and possible pathways to address. Circular economy and migration patterns.	– Field visit** – Group discussions in class – Assignment	3 4 1
3	***Rural and local Institutions***	Traditional rural and community organisations, Self-help Groups, Panchayati raj institutions (Gram Sabha, Gram Panchayat, Standing Committees), Nagarpalikas and municipalities, local civil society, local administration.	How effectively are Panchayati Raj and Urban Local Bodies (ULBs) institutions functioning in the village? What would you suggest to improve their effectiveness? Present a case study (written or audio-visual).	– Classroom – Field visit** Group presentation of assignment	2 4 2
4	***Rural and National Development Programmes***	History of rural development and current national programmes in India: Sarva Shiksha Abhiyan, Beti Bachao, Beti Padhao, Ayushman Bharat, Swachh Bharat, PM AwaasYojana, Skill India, Gram Panchayat Decentralised Planning, National Rural Livelihood Mission (NRLM), Mahatma Gandhi National Rural Employment Guarantee Act 2005 (MGNREGA), SHRAM, Jal Jeevan Mission, Scheme of Fund for Regeneration of Traditional Industries (SFURTI), Atma Nirbhar Bharat, etc.	Describe the benefits received and challenges faced in the delivery of one of these programmes in the local community; give suggestions about improving the implementation of the programme for the poor. Special focus on the urban informal sector and migrant households.	– Classroom – Each student selects one program for field visit** Written assignment	2 4 2

After completing this two-credit course (one credit theory and one credit fieldwork), PG students can undertake a field project for an additional two credits on any one topic appropriate to their regional community context.

Assessment:

Each student in a Field Diary should maintain readings from e-content and reflections from field visits. Participation in Field Visits should be allocated 30% marks; group field project should have 40% of total marks; presentation of field project findings to the community institution should have 30% of total marks.

अखिल भारतीय तकनीकी शिक्षा परिषद्
(भारत सरकार का एक सांविधिक निकाय)
(मानव संसाधन विकास मंत्रालय, भारत सरकार)
नेल्सन मंडेला मार्ग, वसंत कुंज, नई दिल्ली-110070

ALL INDIA COUNCIL FOR TECHNICAL EDUCATION
(A Statutory Body of the Govt. of India)
(Ministry of Human Resource Development, Govt. of India)
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011-29581000
Website : www.aicte-india.org

F. No. AICTE/P&AP/Misc/2022/ **Dated: 05.08.2022**

CIRCULAR

To

All Vice Chancellors of Technical Universities and
All Directors/ Principals of AICTE Approved Institutions,

Subject: AICTE Guidelines for inclusive education for all including persons with disabilities.

Sir/Madam,

The National Education Policy (NEP) 2020 emphasizes equal opportunity for education for all, irrespective of caste, gender and abilities including Persons with Disabilities (PwDs). The introduction of the National Education Policy 2020 has accelerated the need for creation of an 'inclusive education' system that caters to students with both visible and invisible disabilities. As a step towards inclusive and equitable quality education, the NEP 2020 presents a reasoning case for provisions and implementation plans aimed at promoting accommodation of students with any type of disabilities into the Indian education system. The policy touches several grounds to address issues surrounding identification and engagement of students with disabilities, along with the creation of an enabling ecosystem.

In order to facilitate inclusive digital education for all, including Persons with Disabilities, AICTE has formulated following guidelines to be followed by AICTE Approved Institutions.

1) All AICTE Approved Institutions should establish a Cell known as "Equal Opportunity Facilitation Cell (EOFC)" with the following composition:

Sr. No.	Designation	EOFC
1.	Senior faculty	Nodal officer/Coordinator of EOFC
2.	Male/Female faculty	Member
3.	Male/Female Non-Teaching staff	Member
4.	Male/Female student	Member
5.	Representative of NGO working in the area of Empowerment of PWDs	Member
6.	Registrar/Admin officer	Member Secretary

The roles and responsibilities of the above Cell are summarized below:

a) To promote admission of PwDs in technical institutions.
b) To Create awareness among stakeholders in the area of equal opportunities on a regular basis.
c) To address special needs of the students pertaining to teaching-learning process.
d) To provide special assistance in training and placement of students with disabilities.
e) To provide free laptops and internet charges to PwDs through Institute/State Government.
f) To establish a teacher-mentor scheme for PwDs right from entry to exit from the institute.
g) Develop disabled friendly teaching-learning process making use of modern tools and assistive technologies.

2) **Infrastructure Facility for Access to Persons with Physical Disabilities:**
   a) Wheelchair users can move without others help -provision of Ramps with minimum width of 1.5 Meters along with handrails at entrances, exits and passages.
   b) Adequate space (1.2 Meters) is required for movement of wheelchair users to enter into classrooms, laboratories, toilets and other areas within the building.
   c) Ramp slope is 1:12 for climbing by wheelchair users, even when they have a caregiver to push, steep slopes can be painful.
   d) Provision of lifts to accommodate wheelchair users to move different floors.
   e) Handrails for persons who use Crutches with anti-skid (non-slip) floor.
   f) Adequate space for turning.
   g) Accessible toilets with provision of hand rails in urinals, wheelchair access to utilities like washbasin, health facets, etc.
   h) Provision of Signages for easy movement.
   i) Reserved assembly area during emergencies such as accessible emergency fire alarms with flashing lights.
   j) Reserved designated parking.

3) **Facility for Access to Persons with Hearing Impairments:**
   a) Provision of information board in an easily understandable manner.
   b) Good acoustics in the classroom environment (Noisy fans can be distracting to persons wearing hearing aids).
   c) Provision of signages, layout map for movement to the desired place.
   d) Proper signages for emergency exits.
   e) Reserved designated parking.

4) **Facility for Access to Persons with Visual Impairments:**
   a) Provision of Braille Signages including tactile paving.
   b) Unobstructed covered corridors with handrails.
   c) Removal of protruding objects and low level roofing.
   d) Reserved designated parking.

5) **Provision of Accessible Teaching-Learning Process for Persons with Disabilities:**
   To be able to achieve this goal, every Institution should create a cell/unit with the primary objective of ensuring inclusion of students with disability in the teaching-learning process. These cells be adequately funded both in terms of required resources as well as trained manpower. These units should also monitor progress by taking periodic feedback from students with disability. Training a large number of teachers who have full-time/part-time responsibility towards these activities itself is a challenge and special SWAYAM Courses are being proposed for the same. These teachers should be familiar with "accommodation" solutions for enrolled students even if the Institution is not fully accessible. Institutions should make following provisions:
   a) Provision of Sign Language Interpreters wherever required
   b) Use of 'Universal design techniques'. There should be multiple modes of expression and reception. For example, concept should be conveyed in text, audio visual, mindmaps and practical (learning by doing) format in teaching-learning process.
   c) Clear lighting for the speakers to facilitate hearing impaired for lip reading and also use of sound amplification system like microphone by teacher
   d) Issue of notes / handouts in advance to the students in accessible digital format such as Microsoft word or LibreOffice document.
   e) Creation of Peer-Groups within the class for learning among students.

f) Training of teachers in communication skills for handling differently abled.
g) Development and use of E-learning resources embedded with sign language interpretation and subtitles.
h) Provide service of conversion of required instructional materials into accessible format such as accessible digital format, large print, braille, tactile graphics etc. (In-house conversion facility can be established or tie-ups with conversion service providers can be done).
i) Subscription to online sources of accessible format books such as Sugamya Pustakalaya, book share and ABC global book service by the institution and to register each student with print disability on these platforms.
j) Provide digital book reading device to each student/faculty with print disability such as laptop with screen reading software, smart phone, refreshable braille display, DAISY player, etc. free of cost or on subsidy by the institution or through scheme of government of India or by partnering with social groups or civil society organizations along with training to use them.
k) Suitable modifications in the curriculum to suit the needs of differently abled. (Eg. Manual drawing may be replaced with CAD etc.)

6) Special Provisions for Persons with Disabilities in the Examination:

Different examinations/boards have their own guidelines for persons with disability. They also tend to get revised periodically. Again the provisions mentioned here do not replace/override those as they apply to specific boards/examinations. Use these as quick reference and made provisions for:

a) Provision of scribes for students who find difficulty in writing, visual impairments etc. by the examination authority or bring their own scribes during examinations both Common Entrance Tests and institute / University exams.
b) Scribes to be provided as per the guidelines issued by the Department of Empowerment of Persons with Disabilities, Government of India.
c) Extension of time up to 20 minutes per hour should be given to the students who use scribes and students find difficulty in writing examinations.
d) 20 to 50% of questions of objective type in the question paper.
e) Permit and make adequate arrangements for Use of computers for writing examinations by persons with print disabilities with provision of softcopy of question paper in accessible format.
f) Separation of answer scripts for valuation (Considering the level of disability/ use of scribes etc).

7) Disability Support Systems:

Disability Support Unit (DSU) at institute level should be set up when differently abled students are admitted by the institute to provide support in terms of:

a) Financial Assistance (Scholarships, sponsorships)
b) Counselling & Career Guidance
c) Sign Language Development, Training and Interpretation support.
d) Awareness and provision of Assistive devices / Technologies
e) Special Health care support (Depends on type of disability)
f) Regular follow-up on the students, to see if they are using their AT devices well, if any accessibility modifications are needed

g) Training of trainers
h) Create awareness on disability issues
i) Encourage student projects, Research & Rehabilitation focused on disability issues and challenges.

8) **Additional Support and Linkages:**
a) Tie-ups with NGOs who are dealing with differently abled.
b) Placement & support services.
c) Employer Sensitization.
d) Awareness on Disability rights and reservation policies.
e) Community reach programmes.
f) Implementation & Monitoring of standards of Accessibility.
g) Disability Database Management System.
h) Internship and Career Advancement activities:

9) **Facility for Students with Specific Learning Disabilities(SLDs):**

Dedicated **Centers of Learning Diversity (CLD)** may be set up to help with the implementation of the initiatives and provide the requisite support *within* the institute. The mandate of these centers **would be to advocate and to support the learning journey of students with SLDs, including enforcing the provisions for accommodations, providing support services, and access to assistive devices** for students with SLD. The **Hub-and-Spoke Model** with **National Nodal centers** can be employed to support institutions in the establishment of CLDs in HEIs.

a. A dedicated **team to generate awareness**, promote advocacy and create visibility of the proposed support programme at institute/ university level.
b. Implement **capability maturity model** to empower and strengthen the various stakeholders involved in the process of inclusion for students with SLD in higher education institutions in India. **Training & Capacity Building Programs** for faculty, administration teams and other stakeholders must be offered to enable them to create inclusive learning environments for students with SLDs.
c. **Awareness & Advocacy** programmes for students, parents and educators for the inclusion of SLDs must be undertaken. These programmes should address the needs of students aspiring to pursue higher education while enabling them to self-advocate for their needs and rights.
d. **Assistive Technology tools** (hardware and software) should be made accessible for students with SLD for their academic purposes during their years at the HEI. Investment in research and development of appropriate technologies may also be provided.
e. **Admissions:** Streamline the admissions processes to ensure that Institute provides requisite accommodations for students with SLDs and look beyond the "exam performance based" admission criteria.
f. **Accommodations** to be mandated for students with SLDs which would include in-class support, use of technology, accessible study material, examination/testing adjustments.
g. **Dedicated Centre of Learning Diversity** (CLD) may be set up to provide the requisite support to students and faculty, advocate for the students, generate awareness and create visibility of the proposed support program at university level. A capability maturity model is recommended to empower and strengthen the various stakeholders involved.

h. **Assistive Technologie** to be made available for students with SLDs for academic purposes during their study years at the HEI. Investment in research and development of appropriate technologies may also be provided.

All AICTE approved institutions are required to include the details related to the availability of barrier-free environment for students with disabilities on their websites including details of the admission process, support services available and status of Persons with Disabilities (PwDs). Institute should create a separate budgetary head covering the expenditure towards activities promoting inclusion of Persons with Disabilities (PwDs).

It is pertinent to mention here that UGC has come out with Comprehensive Accessibility Guidelines for Higher Educational Institutions and it is suggested that All AICTE Institutions should take cognizance of UGC Guidelines and should also take into consideration while implementing AICTE Guidelines. Further details on UGC guidelines may be accessed from UGC web portal https://ugc.ac.in/pdfnews/8572354_Final-Accessibility-Guidelines.pdf.

Regards

(Dr. Ramesh Unnikrishnan)
Advisor-II
Policy & Academic Planning
Bureau

Annexure 67.41 (a)
of 67th meeting of the IAAC

SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY (SVNIT), SURAT

Academic Calendar for First year of M. Tech. and Ph.D

AUTUMN SEMESTER (ODD SEMESTER): A. Y. 2024-25

	Activity	**Week**	**Duration**
1	Commencement of Teaching	1	Aug 12, 2024
2	Orientation Programme		Aug 30-31, 2024
3	Mid Semester Examination	10	Oct 14-19, 2024

The teaching Schedule of **one-week classes** will be adjusted on the weekdays from 02.09.2024 to 11.10.2024 before the mid-semester exam. Similarly, the teaching schedule of **another week's classes** will be adjusted on weekdays from 21.10.2024 to 22.11.2024 after the mid-semester exam, at the vacant slots. The concerned HoD will issue the timetable with a copy to the Dean (Academic). If the slots are unavailable within the regular schedule of weekdays, the concerned HoD may decide on a suitable time, either in the evening or on Saturday.

For remaining activities:
https://www.svnit.ac.in/Data/Notice/2024/May/Academic%20calendar%202024-25.pdf

Dean (Academic)

Annexure 67.41 (b)
of 67th meeting of the IAAC

SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY (SVNIT), SURAT

Academic Calendar for First year of B. Tech. and M. Sc.

AUTUMN SEMESTER (ODD SEMESTER): A. Y. 2024-25

	Activity	Week	Duration
1	Orientation Programme		Aug 16-18, 2024
2	Commencement of Teaching	1	Aug 19, 2024
3	Mid Semester Examination	10	Oct 14-19, 2024

The teaching Schedule of **one-week classes** will be adjusted on the weekdays from 02.09.2024 to 11.10.2024 before the mid-semester exam. Similarly, the teaching schedule of **another week's classes** will be adjusted on weekdays from 21.10.2024 to 22.11.2024 after the mid-semester exam, at the vacant slots. The concerned HoD will issue the timetable with a copy to the Dean (Academic). If the slots are unavailable within the regular schedule of weekdays, the concerned HoD may decide on a suitable time, either in the evening or on Saturday.

For remaining activities:
https://www.svnit.ac.in/Data/Notice/2024/May/Academic%20calendar%202024-25.pdf

Dean (Academic)

Annexure 67.42
of 67th the meeting of the IAAC

Sardar Vallabhbhai National Institute of Technology, Surat-395007

Department of Civil Engineering

Urban Planning Section

AMURT Funded Centres of Urban Planning for Capacity Building by the Ministry of Housing and Urban Development

Urban Planning Section of DoCE, SVNIT has awarded AMRUT Funded Centres of Urban Planning for Capacity Building' by the Ministry of Housing and Urban Affairs, Government of India for developing capacities in urban planning and to deliver certified training in these areas vide letter K-14011/6/2024-AMRUT –IIA dated 06/06/2024.

- The centre is fully funded from grant of the AMRUT 2.0.
- Grant of Rs.5 crore per year will be given to the AMRUT Funded Centres for Capacity Building for the initial 2 years.
- Funds will be released in 4 instalments of 25% each. A view on increasing the grant will be taken in subsequent years based on the performance of the institutes and utilisation of funds.
- There will be no financial assistance from institute (SVNIT, Surat).
- There is no financial component of capital expenditure on infrastructure and instrument hence there will no financial obligation of maintenance and repair on SVNIT, Surat.

Following are the point wise action taken by the Urban Planning Section

Sr. No.	Particulars	Current Status
1	Action plan indicating areas of expertise	• Details are submitted during the first submission for the application of "Center of Urban Planning". 1. Preparation of GIS based Town Planning Scheme 2. Climate Resilience Master Plan integrating AI, ML and GIS 3. Preparation of Local Area Plan for Achieving SDGs
2	Subject-wise capacity building programmes proposed to be conducted	• Subject-wise capacity building programmes proposals are submitted with original documents. • The work is in progress for micro planning of the Subject-wise capacity building programmes.

(1/2)

3(A)	Identify at least 2 cities in state to be undertaken in first years	• Surat • Navsari • Valsad • Silvassa • Vyara are short listed soon.(any Two)
3(B)	Specific projects catering to challenges and issues of the cities to be undertaken in first years	• Work in Progress. • Specific projects catering to challenges and issues of the cities to be undertaken in first years will finalized with the coordination with local government. • Once cities are identified. (Reference: Para 3(A))
4	Action plan need to submit within one month	• For preparation of "Action Plan"- Under Secretary, MoHUA (AMRUT division), Government of India is providing the suggestion and guideline during the meetings. (Will be finalized in next meetings)
5	Team leader's name, designation, email and mobile no.	• Details are submitted through email. (Copy Attached)
6	Draft MoU specifying terms and conditions for availing grant will be shared with Institute shortly by Ministry.	• Draft MoU will be released by the office of Under Secretary, MoHUA (AMRUT division), Government of India

Dr Chetan R Patel
Associate Professor
PG I/C Urban Planning
DoCE, SVNIT, Surat

Dr K.A Chauhan
Professor and Section Head,
Urban Planning, DoCE, SVNIT, Surat

K-14011/6/2024-AMRUT-IIA
Government of India
Ministry of Housing & Urban Affairs
(AMRUT Division)

Nirman Bhawan, Maulana Azad Road,
New Delhi, Date: 6th June , 2024

To,

1. **The Director, School of Planning and Architecture, Bhopal**
2. **The Head, Department of Architecture & Planning, Indian Institute of Technology, Roorkee**
3. **The Head, Guru Ramdas School of Planning, Guru Nanak Dev University, Amritsar**
4. **The Director, School of Planning and Architecture, Vijayawada, Andhra Pradesh.**
5. **The Director, SVNIT, Surat**
6. **The Director, Malaviya National Institute of Technology, Jaipur**

Subject: Recognition of Institutes as "AMRUT Funded Centres of Urban Planning for Capacity Building' by the Ministry of Housing and Urban Development – regarding.

Sir,

I am directed to convey approval of the Government for designation of the Institutes as **'AMRUT Funded Centres of Urban Planning for Capacity Building'** by the Ministry of Housing and Urban Affairs, Government of India for developing capacities in urban planning and to deliver certified training in these areas. The Institutes will be required to sign an MoU with the Ministry for availing grant for the purpose. Grant of Rs.5 crore per year will be given to the AMRUT Funded Centres for Capacity Building for the initial 2 years. Funds will be released in 4 installments of 25% each. A view on increasing the grant will be taken in subsequent years based on the performance of the institutes and utilisation of funds.

2. The institutes are requested to submit the following:
   (i) Action plan indicating areas of expertise.
   (ii) Subject-wise capacity building programmes proposed to be conducted.
   (iii) Identify at least 2 cities in a State/ States and specific projects catering to the challenges and issues of the Cities to be undertaken in the first year.

3. The Action Plan may be submitted within one month. It is also requested that a Head/ Team leader for the AMRUT Funded Centres of Urban Planning for Capacity Building may be identified and his/ her name, designation, email and mobile no. may be conveyed to the Ministry (email: ravi.chandra@nic.in , isha.ias09@ias.gov.in) for further coordination. Draft MoU specifying the terms and conditions for availing the grant will be shared with the institutes shortly.

Yours sincerely,

(Ravi Chandra)
Under Secretary to the Government of India
Tele: 2306 1407