DEPARTMENT OF
MECHANICAL ENGINEERING

M.TECH. (MECHANICAL ENGINEERING)

FOR WORKING PROFESSIONALS

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.

M. Tech. Programme for Working Professionals (Mechanical Engineering)
Course Structure and Scheme of Evaluation (Semester wise)

Sr. No.	Subjects	Code	Scheme* L-T-P	Credits (Min.)
		First Semester		
1.	**Core-** Advanced Thermal and Fluid Engineering	MEME105	3-0-2	4
2.	**Elective-** Elective-1	--	3-0-0	3
	Electric Vehicles and Advanced I C Engines	MEME111		
	Additive Manufacturing	MEME113		
	Advanced Vibrations in Rotor Systems	MEME115		
	Industrial Tribology	MEME117		
	Power Plant Engineering	MEME119		
			Total	**7**
		Second Semester		
1.	**Core-** Computer Integrated Manufacturing	MEME102	3-1-2	5
2.	**Elective-** Elective-3	--	3-0-0	3
	Renewable Energy Systems	MEME112		
	Design of Pressure Vessels	MEME114		
	Theory and Design of Cryogenic Systems	MEME116		
	Quality Engineering and Management	MEME118		
	Advanced Welding Technology	MEME120		
			Total	**8**
		Third Semester		
1.	**Core-** Computer Aided Engineering	MEME103	3-0-2	4
2.	**Elective-** Elective-2	--	3-0-0	3
	Optimization Techniques	MEME121		
	Industrial Robotics	MEME123		
	Concurrent Engineering	MEME125		
	Computational Fluid Dynamics	MEME127		
	Design of Refrigeration and Air ConditioningSystems	MEME129		
	Operation Planning and Control	MEME131		
			Total	**7**

Fourth Semester				
1.	**Core-** Mechanical Design Analysis	MEME104	3-1-0	4
2.	**Elective-** Elective-4	--	3-0-0	3
	Design of Experiments	MEME122		
	Design and Analysis of Composite Structures	MEME124		
	Combustion for Propulsion Systems	MEME126		
	Design of Heat Exchangers	MEME128		
	Non Destructive Testing	MEME130		
3.	**Mini Project**	MEME106	0-0-4	2
			Total	**9**
Fifth Semester				
1	Seminar	-	-	4
2.	Dissertation preliminary	MEME295		16
3				
			Total	**20**
Sixth Semester				
1.	Dissertation	MEME296		**20**
				71+08**
			Total	**79**

* Scheme 3-0-2/ 3-1-2/3-0-0/3-1-0

**Two SWAYAM/ NPTEL (MOOC) Courses of 8 credits as decided by the DAAC of the respective department be completed within first two years.

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

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: 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.	**(15 Hours)**
3-D Modeling: 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.	**(15 Hours)**
Numerical Analysis: 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.	**(15 Hours)**

(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.

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. <u>Books Recommended:</u>

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.

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).

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: Overview of various parts of pressure vessels, classification of pressure vessels, applications, factors influencing the design of vessels - material selection, loads & types of failures.	**(11 Hours)**
Stresses in pressure vessels: 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	**(11 Hours)**
Design of pressure vessels as per ASME and IS code: Introduction and importance of codes, Externally and internally pressurized vessels, tall vertical vessels, Supports for vertical & horizontal vessels, nozzles and flanges. shells and heads	**(12 Hours)**
Pressure vessels with different conditions: Evaluation of pressure vessels for different conditions: hydro-test condition, thermal stresses, FEM analysis, Fatigue of pressure vessels.	**(11 Hours)**

(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

MEME103	:	COMPUTER AIDED ENGINEERING	L	T	P	Credits
			3	0	2	04

2. 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: 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.	**(15 Hours)**
3-D Modeling: 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.	**(15 Hours)**
Numerical Analysis: 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.	**(15 Hours)**

(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

14. Sketching of conceptual design through Drafting of a given engineering component
15. Programming In drafting for a given sketch or mechanical component
16. Creating a 3d model of mechanical components exploring various features of CAD tools.
17. Developing relational sketches and model for designing mechanical components.
18. Creating communication drawing using generative approach for manufacturing requirement of given engineering part or product.
19. Creating assemblies for designing digital product through CAD software.
20. Creating a digital models and surfaces of non-geometric nature through parametric curves.
21. Creating presentation animation for digital communication of engineering products.
22. Solving linear problem for a given engineering problems using 1D approach using FEM software
23. Solving linear problem for a given engineering problems using, 2D approach using FEM software
24. Solving linear problem for a given engineering problems using 3D approach using FEM software
25. Demonstrating FEM software for Nonlinear problems using FEM software
26. Solving given engineering problem using FDM by computation approach.

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. 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, 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. Books Recommended:

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

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: 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.	**(06 Hours)**
Design for Fatigue Strength: 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.	**(10 Hours)**
Thermal Properties and Stresses: 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.	**(10 Hours)**

Design of Brakes and Clutches: 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.	**(09 Hours)**
Design of Bearings and Power Transmission Elements: 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.	**(10 Hours)**

(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.

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. <u>Books Recommended:</u>

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 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	**06 hours**
Macro-Mechanical Behaviour of a Lamina 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	**07 hours**
Micro-Mechanical Behaviour of a Lamina Mechanics of materials approach to stiffness, Elasticity approach to stiffness, Mechanics of materials approaches to strength.	**06 hours**
Macro-Mechanics Behaviour of a Laminate Classical laminate theory, Special cases of laminate stiffness, Theoretical versus measured laminate stiffness, Strength of laminates, Interlaminar stresses	**07 hours**
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 Introduction, Introduction to structural design, Material Selection, Configuration Selection, Laminate joints, Design requirements and design failure criterion	**09 hours**

(Total Lecture Hours: 45)

3. <u>Books Recommended:</u>

1	K. K. Autar. Mechanics of composite materials, 2^{nd} Edition, CRC Press, 2006.
2	R. M. Jones. Mechanics of composite materials, 2^{nd} 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 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.	**(04 Hours)**
THERMODYNAMICS OF COMBUSTION 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.	**(08 Hours)**
COMBUSTION KINETICS 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.	**(08 Hours)**
CHEMICAL MECHANISMS Explosive and oxidative characteristics of fuels, Criteria for explosion, Explosion limits and oxidation of hydrogen, Carbon monoxide and hydrocarbons.	**(03 Hours)**

PREMIXED FLAMES 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.	**(06 Hours)**
DIFFUSION FLAMES 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.	**(06 Hours)**
COMBUSTION AND ENVIRONMENT 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.	**(04 Hours)**
COMBUSTION PROCESS IN PROPULSION SYSTEMS Principal ideas of combustion in gas turbine, solid propellant rockets: Erosive burning, and liquid propellant rockets.	**(06 Hours)**

(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

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.