Teaching and Examination Schemes with Syllabus

of

Master of Technology (Civil)

in

Transportation Engineering and Planning

As per NEP

(Approved by 62nd meeting of Senate dated August 6, 2024)

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

CETP111Low Volume Roads
CETP112Transportation System Analysis
CETP113Sustainable Transportation
CEGT110Geosynthetics and Reinforced Soil Structures
CETP114 Highway geometric Design
CETP115 Geospatial Techniques in Transportation Engineering

Elective-II

CETP116Airport Infrastructure Planning and Design
CETP117Railways Infrastructure Planning & Design
CETP118Pavement Materials
CETP119 Waterways Infrastructure Planning & Design
CETP120Transport Economics
CETP121 Transportation Network Analysis
CETP122 Road Safety and Environment

Elective-III

CETP123Freight Transportation Planning
CETP124Public Transport Planning
CETP125 Traffic Flow Theory
CETP126Operation & Maintenance Management of Pavements
CEGT127 Ground Improvement Techniques
CEGT128 Tunneling and Underground Structures

Institute Elective offered by TEP section:

CECT171Project Appraisal & Finance
CETP172Soft Computing Techniques
CETP173Intelligent Transport System
CETP174 Communication Skills
CECS175AI/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

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- **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," 7th 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 GEOSPATIALTECHNIQUES IN TRANSPORTATION ENGINEERING

Pre Requisite Courses: Nil

L	T	PC	
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

- **INTRODUCTIONTOGEOINFORMATICS (05Hours)**
  Concepts and fundamentals, energy sources, energy interactions, ideal and real remotesensing systems, fundamentals of aerial photo interpretation, keys, Dataacquisition,variousremotesensingplatforms, Basic concepts of GIS & GPS, Digitalimageprocessing.
- **GEOGRAPHICALINFORMATIONSYSTEM (08 Hours)**
  StructureofGIS:Cartography,Geographicmappingprocess,transformations,mapprojections, Geographic Data Representation, Storage, Quality and Standards, databasemanagementsystems,Rasterdatarepresentation,Vectordatarepresentation,Assessment ofdataquality,Managingdataerrors,Geographic datastandards.
- **DATAHANDLINGIN GIS (08Hours)**
  GIS Data Processing, Analysis and Modeling: Raster based GIS data processing – Vectorbased GIS data processing – Queries – Spatial analysis – Descriptive statistics – Spatialautocorrelation–Quadrantcounts,andnearestneighbouranalysis–Networkanalysis.

- **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.
- **GLOBALPOSITIONINGSYSTEM (08Hours)**
  GPS:Basicconcepts,components,factorsaffecting,GPSsetup,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, GPSapplications,Casestudies.
- **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.

(Totalhours:45)

REFERENCES:

1. Lo,C.P.&YeungA.K.W.,*ConceptsandTechniquesofGeographicInformationSystems*,PrenticeHall ofIndia, NewDelhi, 2002.
2. Kang-tusang Chang, Introduction to Geographic Information Systems, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2002.
3. AnjiReddy,M.,*RemoteSensingandGeographicalInformationSystems*,B.S.Publications,Hyderaba d,2001.
4. Burrough,P.A.,*PrinciplesofGeographicalInformationSystems*,OxfordPublication,1998.
5. Clarke,K.,*GettingStartedwithGeographicInformationSystems*,PrenticeHall,NewJersy,2001.
6. DeMers,M.N.,*FundamentalsofGeographicinformationSystems*,JohnWiley&Sons,NewYork, 2000.
7. KennedyM.,*TheGlobalPositioningSystem&GIS:AnIntroduction*,AnnArborPress,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.**

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.

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

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

CECS175 AI/ML BASED APPLICATIONS IN CIVIL **L T P C**

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,andAnalysis of processed data,

(Total Contact Hors: 45)

3. Books Recommended:

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. Other Material:

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.