COEP Technological University Pune

(A Unitary Public University of Govt. of Maharashtra)

School of Civil Engineering and Planning

Curriculum Structure

F. Y. M. Tech.

(Regular)

Transportation Engineering

(Effective from: A.Y. 2023-24)

Program Educational Objectives

I. Graduates of the program will have in-depth knowledge to identify and formulate challenging problems in transportation engineering, apply appropriate research methodologies, use modern engineering tools and provide technically sound, economical and sustainable solutions.

II. Graduates will have the ability for higher studies and undertake high value research on transportation engineering and other related issues.

III. Graduates of the program will have sound analytical and lateral thinking ability to engage in lifelong learning for professional advancement to cope up with multidisciplinary and changing technologies in transportation engineering.

IV. Graduates of the program will have a sense of social responsibility, will demonstrate the ability to communicate and work effectively as a team member in an ethical way, and will play leadership roles in their profession, public services and community.

Program Outcomes

On completion of the program students will be able to

PO1: Apply the knowledge of science, mathematics, and engineering principles for developing problem solving attitude, independently carrying out research /investigation and development works.

PO2: Write and present a substantial technical report / document.

PO3: Demonstrate a degree of mastery in transportation engineering. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO4: Gain knowledge / skill in transportation engineering for collaborative multidisciplinary solutions and carry out planning and management of projects as a member and a leader in a team considering economic and financial factors.

PO5: Recognize the need for and have ability in lifelong learning independently for professional advancement, demonstrate professional ethics, work culture and understanding of responsibility to contribute to community for sustainable development of society.

List of Abbreviations

Abbreviation	Title	No of courses	Credits	% of Credits
PSMC	Program Specific Mathematics Course	1	4	5.9
PSBC	Program Specific Bridge Course	1	4	5.9
PEC	Program Elective Course	3	9	13.2
MLC	Mandatory Learning Course	2	0	0.0
PCC	Program Core Course	5	16	23.5
LC	Laboratory Course	5	7	10.3
UOE	University Open Elective	1	3	4.4
LLC/CCA	Liberal Learning Course/ Co-curricular & Extracurricular Activities (CCA)	1	1	1.5
SLC	Self-Learning Course	2	6	8.8
SBC	Skill Based Course	2	18	26.5

F.Y. M. Tech. in Transportation Engineering

Semester -I

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1.	PSMC	CTE-23001	Probability and Data Analysis	3	1	-	4
2.	PSBC	CTE-23002	Traffic Engineering and Management	4	-	-	4
3.	PEC		**Elective – I**	3	-	-	3
		CTE(PE)-23001	1. Low Volume Roads				
		CTE(PE)-23002	2. Sensors and Automation				
		CTE(PE)-23003	3. Highway Geometric Design				
		CTE(PE)-2300	4. Advances in Docks and Harbour Engineering				
		CTE(PE)-23005	5. Airport Infrastructure Planning and Design				
		CTE(PE)-23006	6. Any course approved by BOS				
4.	PCC	CTE-23003	Highway Materials	3	-	-	3
5.	PCC	CTE-23004	Highway Geotechnology	3	-	-	3
6.	LC	CTE-23006	Transportation Engineering Lab - I	-	-	4	2
7.	LC	CTE-23007	Transportation Engineering Lab - II	-	-	2	1
8.	LC	CTE-23008	Seminar	-	-	2	1
			Total	**16**	**1**	**8**	**21**

Semester -II

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1.	UOE	OEC	University level Open Elective	3	-	-	3
2.	PEC		**Elective – II**	3	-	-	3
		CTE(PE)-23007	1. Sustainable Construction Engineering				
		CTE(PE)-23008	2. GIS and Remote Sensing for Transportation				
		CTE(PE)-23009	3. Pavement Construction and Evaluation				
		CTE(PE)-23010	4. Rail and Metro Construction				
		CTE(PE)-23011	5. Freight Transportation Planning and Logistics				
		CTE(PE)-23012	6. Intelligent Transportation Systems				
		CTE(PE)-23013	7. Any course approved by BOS				
3.	PEC		**Elective – III**	3	-	-	3
		CTE(PE)-23014	1. Artificial Intelligence and Machine Learning Applications for Transportation Engineering				
		CTE(PE)-23015	2. Traffic Flow Modelling and Simulation				
		CTE(PE)-23016	3. Sustainable Transportation				
		CTE(PE)-23017	4. Design of Underground Structure				
		CTE(PE)-23018	5. Public Transportation Planning				
		CTE(PE)-23019	6. Highway Financing and Policy Analysis				
		CTE(PE)-23020	7. Any course approved by BOS				
4.	LLC	LL	Liberal Learning Course	1	-	-	1
5.	MLC	ML-23001	Research Methodology and Intellectual Property Rights	2	-	-	-
6.	PCC	CTE-23009	Highway Structures	3	-	-	3
7.	PCC	CTE-23010	Analysis and Design of Pavement	4	-	-	4
8.	PCC	CTE-23011	Road Safety and Road Safety Audit	3	-	-	3
9.	LC	CTE-23012	Transportation Engineering Lab - III	-	-	4	2
10.	LC	CTE-23013	Mini Project	-	-	2	1
			Total	**22**	**-**	**6**	**23**

Semester III

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1.	SBC		Dissertation Phase- I	-	-	18	9
2.	SLC		Massive Open Online Course (MOOC)- I	3	-	-	3
			Total	**3**	**-**	**18**	**12**

Semester IV

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1.	SBC		Dissertation Phase- II	-	-	18	9
2.	SLC		Massive Open Online Course (MOOC)- II	3	-	-	3
			Total	**3**	**-**	**18**	**12**

Note:*** Exit option to qualify for PG Diploma in Transportation Engineering
*Eight weeks domain specific industrial internship in the month of June-July after successfully completing first year of the program

Civil Engineering Department,
Post Graduate Syllabus Structure 2023-24

M. Tech Transportation FIRST YEAR

Semester I

CTE-23001 Probability and Data Analysis	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/ week	**T1 and T2 -** 20 marks each
Tutorial: 1hr/week	**End Sem. Exam.** - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Determine appropriate statistical methods in transportation engineering problems.
CO 2: Apply the rule of probability and discrete distributions in solving problems.
CO 3: Evaluate the goodness of fit by using statistical decision.
CO 4: Apply the knowledge of optimization technique and use statistical software in analysis of transportation engineering problems

Unit 1	**Introduction**	**[8 Hrs]**
	Statistical methods, scope and limitations, population and sample, frequency distribution-measure of central tendency-measures of Dispersion- standard deviation, coefficient of variation, skewness. Variables - scatter diagram, Curve fitting methods, correlation linear regression, and multiple linear regressions. Multivariate data analysis.	
Unit 2	**Probability**	**[8 Hrs]**
	Review, Addition & Multiplication Rules, random Variables, Discrete distributions – Binomial, Poisson, Geometric, Hypergeometric Distribution, Continuous Distribution –Exponential, & normal Distributions, applications in Highway engineering problems.	
Unit 3	**Statistical decisions**	**[8 Hrs]**
	Hypothesis testing, significance levels – Tests concerning Mean, testing the equality of means of two populations, tests concerning the variance. Chi–square Test for goodness of fit, The Z-Score Test, The T-Test, Confidence Interval. Forecasting and Time Series Analysis Problems	
Unit 4	**Linear Programming:**	**[8 Hrs]**
	Methods for maximizing, methods for minimizing, etc. Transportation models, assignment model, queuing theory, Applications in Transportation engineering, Use of mathematical and statistical software packages	

References

1. Gupta, S.C. and Kapoor V.K. Fundamentals of Mathematical statistics, Sultan Chand and Sons, 1978.
2. Medhi J (1982) Introduction to statistics. New age publications, New Delhi.
3. Walpole R. E. and R. H. Mayers (1982): Probability and statistics for Engineers and Scientists. Wiley Intl. 2002.
4. Johnson R and G. Bhattacharya (1985): Statistics -Principles and methods. John Wiley, NY.
5. Ross S. M. Probability and statistics for Engineers. Wiley Int. Edition.
6. Kadiyali L.R. Traffic Engineering and Transport Planning, Khanna Publishers, 2004

CTE-23002 Traffic Engineering and Management	
Teaching Scheme	**Examination Scheme**
Lectures: 4 Hrs/ week	**T1 and T2 -** 20 marks each
Tutorial: -	**End Sem. Exam.** - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Interpret Traffic Stream Characteristics and Sensing Technologies.
CO 2: Analyze Traffic Volume and Fundamental Flow Relationships.
CO 3: Interpret Traffic Flow Parameters and Capacity Concepts.
CO 4: Demonstrate Traffic Intersection Control and Traffic Signal Design Principles.
CO 5: Conduct Specialized Traffic Studies, including Parking Analysis and Shockwave Propagation.

Unit 1	**Traffic stream characteristics**	**[7 Hrs]**
	Introduction, Human-vehicle-environment system, Road user and vehicle characteristics, Traffic Sensing Technologies: Traffic Sensors, Traffic Sensor Classification, Data Sources: Mobile Sensor Data, Point Sensor Data, Space Sensor Data, Time-Space Diagram and Characteristics: Time and space headways, gaps, clearance, temporal, spatial and flow patterns; speed characteristics, Traffic Volume: Computation of Annual Average Daily Traffic (AADT), Annual Average Weekly Traffic (AAWT), Average Daily Traffic (ADT), Average Weekly Traffic (AWT), Design Hourly Volume from Short and Long Term Counts to develop adjustment factors, Fundamental traffic flow relationships, Moving observer method	
Unit 2	**Traffic Flow Analysis-Part I**	**[7 Hrs]**
	Time Headways, Traffic Stream Parameters and their Relationships, Single-Regime Models, Multi-Regime Models	
Unit 3	**Traffic Flow Analysis-Part II**	**[7 Hrs]**
	Concept of Capacity and Level of Service for Basic Freeway Segments, Multilane Highways, two lane highways as per Highway Capacity Manual (HCM) (2016), Analysis of Capacity and LOS of single, intermediate two lane and multi lane highways as per Indian Highway Capacity Manual (Indo-HCM) (2017)	
Unit 4	**Traffic intersection control**	**[7 Hrs]**
	Principles of Traffic Control and Traffic Signs, Road Markings and Channelization, Uncontrolled Intersection: Gap acceptance and capacity concepts, Uncontrolled Intersection: Capacity and LOS analysis, Traffic Rotaries and Grade Separated Intersection.	
Unit 5	**Traffic signal design**	**[7 Hrs]**
	Design Principles of Traffic Signal, Evaluation of a Traffic Signal: Delay Models, Capacity and LOS Analysis of a Signalized I/S, Coordinated Traffic Signal, Vehicle Actuated Signals and Area Traffic Control.	

Unit 6	Specialized traffic studies [6 Hrs]
	Shockwave analysis: Qualitative Analysis, Quantitative Analyis, Propagation of Shockwave, Car following models, traffic microsimulation, Parking Studies, Parking inventory, Statistics, Parking surveys; in out license palate, On-street and off-street parking.

References

1. L. R Kadiyali. Traffic Engineering and Transportation Planning. Khanna Publishers, New Delhi, 2008.
2. Ni, D. Traffic Flow Theory: Characteristics, experimental methods, and numerical techniques. Butterworth-Heinemann, 2015.
3. May, Adolf Darlington. Traffic Flow Fundamentals,1990.
4. Highway Capacity Manual (Sixth Edition). Transportation Research Board. National Research Council, Washington, 2016
5. Indian Highway Capacity Manual (Indo-HCM), 2017
6. Relevant IRC codes

CTE(PE)-23001 Low Volume Roads	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/ week	**T1 and T2 -** 20 marks each
Tutorial: -	**End Sem. Exam.** - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Interpret rural road network plan
CO 2: Evaluate appropriate materials for construction of low volume roads considering cost effectiveness.
CO 3: Design flexible pavement and rigid pavement for low volume roads.
CO 4: Determine the provision of an appropriate road drainage system.
CO 5: Apply an appropriate construction technique with relevant quality control tests

Unit 1	**Planning of Rural Road Network**	**[6Hrs]**
	Significance of rural road network, Characteristics of low volume roads, Features of PMGSY, MMGSY, Network planning of low volume roads.	
Unit 2	**Pavement Materials for Low Volume Roads**	**[6 Hrs]**
	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.	
Unit 3	**Design of Pavements for Low Volume Roads**	**[8 Hrs]**
	Design factors, pavement thickness design as per IRC, design of Semi-rigid pavement, roller compacted cement concrete pavement, special pavements like interlocking- block paving, design of fly ash embankments.	
Unit 4	**Road Drainage**	**[6 Hrs]**
	Types of drainage, surface, and sub-surface drains for low volume roads.	
Unit 5	**Construction Practices for Low Volume Roads**	**[6 Hrs]**
	Specifications for embankment, subgrade, sub-base, base course and surface course, Construction procedures, Construction equipment, Construction of special pavements for low volume roads.	

References

1. IRC, Specifications for Rural Roads, Ministry of Rural Development, Indian Road Congress, New Delhi, 2014, Fifth revision
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 Volume Roads, IRC: SP 62, Indian Road Congress, New Delhi, 2014
4. IRC, Guidelines for the Design of Flexible Pavements for Low Volume Rural Roads, Indian Roads Congress, IRC: SP 72, New Delhi, 2015
5. Guidelines for the Design of Stabilized Pavement, IRC: SP 89 (P-II), Indian Road Congress, New Delhi, 2018

CTE(PPE)-23002 Sensors and Automation	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/ week	**T1 and T2 -** 20 marks each
Tutorial:	**End Sem. Exam.** - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Recognize the working of commonly used sensors for measurement of temperature, position, accelerometer, vibration sensor, flow and level.
CO 2: Identify the application of machine vision.
CO 3: Conceptualize signal conditioning and data acquisition methods.
CO 4: Comprehend smart sensors and their applications in automation systems

Sensors and Transducer: Definition, Classification of transducers, Advantages and Disadvantages of Electrical Transducers.

- Measurement of displacement using Potentiometer, LVDT; Measurement of force using strain gauges & load cells.
- Measurement of pressure using LVDT based diaphragm & piezoelectric sensor, earth pressure cell, Humidity Sensor,
- Proximity sensor: Inductive, Capacitive & Photoelectric, Use of proximity sensor as accelerometer and vibration sensor; temperature sensors (RTD,Thermocouple)
- IR sensors, optical sensor, Corrosion Sensors, acoustic emission sensors, inertial sensor, Fuel sensor
- Imaging Sensors: CCD and CMOS; sensing & digitizing function in machine vision, image processing and analysis.
- Smart Sensor: General Structure of smart sensors & its components, Characteristic of smart sensors ,Application of smart sensors
- Signal Conditioning: Introduction, Functions of signal conditioning equipment, need for amplification of signals,
- Data Acquisition Systems and Conversion: Introduction, Objectives & configuration of data acquisition system, Analog & Digital IO, Counters, Timers, need of data conversion

Industrial Automation: Concept, automation components, necessity and working principle, block schematic of Programmable Logic Controller (PLC). Input & Output modules (AI, DI, AO, DO), Introduction to Ladder Programming, introduction to Distributed Control Systems (DCS). Industrial automation leads to Industrial IOT and Industry 4.0.

References

1. DVS Murthy, Transducers and Instrumentation, PHI 2nd Edition 2013
2. D Patranabis, Sensors and Transducers, PHI 2nd Edition 2013.
3. S. Gupta, J.P. Gupta / PC interfacing for Data Acquisition & Process Control, 2nd ED / Instrument Society of America, 1994.
4. Arun K. Ghosh, Introduction to measurements and Instrumentation, PHI, 4th Edition 2012.
5. A.D. Helfrick and W.D. Cooper, Modern Electronic Instrumentation & Measurement Techniques, PHI – 2001

CTE(PPE)-23003 Highway Geometric Design	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/ week	**T1 and T2 -** 20 marks each
Tutorial: -	**End Sem. Exam.** - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Summarize the factors influencing highway design, including topography and safety.
CO 2: Apply design principles for diverse roads and master street design concepts.
CO 3: Develop proficiency in horizontal and vertical alignment, including curve design.
CO 4: Comprehend visibility requirements and master intersection layout design.
CO 5: Demonstrate principles for designing parking facilities and diverse transportation terminals.

Unit 1	**Introduction**	**[5 Hrs]**
	Design Controls - Topography and physical features, traffic, vehicular characteristics, speed and safety; Space standards for urban, rural and hill roads, Sight distance requirements, Access controls	
Unit 2	**Cross-section Elements**	**[6 Hrs]**
	Single lane, Two lane, Multi-lane highways, Expressways, Urban roads; Street design concepts, bicycle tracks, pedestrian facilities, street furniture, Design of Speed Breaker	
Unit 3	**Alignment**	**[10 Hrs]**
	Horizontal Alignment - Curve design, Super-elevation design, Transition curve design, Attainment of super-elevation, Pavement widening, Sight distance on horizontal curves; Vertical Alignment - Gradients, Grade compensation, Design of vertical curves, Combination of horizontal and vertical alignment, vertical clearance for underpasses and elevated structures	
Unit 4	**Intersection Geometry**	**[6 Hrs]**
	Visibility requirements, Principles of channelization, Layout design for types of intersections, on-ramps and off-ramps (flyovers and Access controlled facilities), Acceleration and deceleration lanes, Two-way tum lanes,	
Unit 5	**Design of Facilities**	**[5 Hrs]**
	Design of on-street and off-street parking facilities, multi-storyed Parking; Design of bus shelters and bus lay-bye, Bus terminal, Truck terminals and truck layby, Container terminal, Toll Plaza, Foot-over bridge and sky-walk	

References

1. Wright, P.H. & Dixon, K.K., "Highway Engineering", 7'h Ed., John Wiley & Sons. 2004
2. Transportation Research Board (TRB), Highways Capacity Manual, National Research Council, Washington D.C. 2010
3. Khisty, C.J. and Lal, B.K., "Transportation Engineering - An Introduction", Prentice Hall of India Pvt. Ltd. 2006
4. Kadiyali, L.R., "Traffic Engineering and Transport Planning", Khanna Publishers. 2008
5. Relevant IRC codes

CTE(PPE)-23004 Advances in Docks and Harbour Engineering	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/ week	**T1 and T2 -** 20 marks each
Tutorial: -	**End Sem. Exam.** - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Analyze global trade's impact on port planning
CO 2: Evaluate tide conditions, breakwaters, and navigability.
CO 3: Create and assess cargo handling and storage designs
CO 4: Apply maintenance strategies to waterways.
CO 5: Evaluate multi-modal transportation and Ro-Ro vessels.

Unit 1	**Introduction**	**[6Hrs]**
	Ports and harbours – an infrastructure layer between two transport media, planning of ports and harbours. Global Trade, GDP impact on EXIM trades, Traffic Studies, Introduction to Micro and Macro analysis	
Unit 2	**The fundamentals and Design issues**	**[6 Hrs]**
	Fundamentals: Tide and current conditions inside harbour, breakwaters, jetties and quay walls; mooring, berthing and ship motion inside the port; model studies, physical and mathematical studies. Design issues: Sea port layout with regards to (1) wave action (2) siltation (3) navigability, berthing facilities.	
Unit 3	**Design of Port Infrastructures**	**[7 Hrs]**
	Design of port infrastructures with regards to (1) cargo handling (2) cargo storage (3) rail road connectivity, planning multipurpose port terminals:- Marine Oil Terminal, Passenger Terminals, Submarine pipe lines, Tank farms, Container Freight Stations, Port based SEZ, Concept of Dry Ports.	
Unit 4	**Port Operations**	**[5 Hrs]**
	Types of Cargo handling and Equipment's, shipping lines for cargo operations, dredging and navigability, hazard scenarios; VTMS and management of computerized container terminal, safety & environment (handling of fire, oil spill, rescue, etc.)	
Unit 5	**Inland Waterways and Ports**	**[5 Hrs]**
	Maintenance of waterways, construction of environmentally engineered banks, disposal processing and storing of polluted dredged materials, development of river transportation.	
Unit 6	**State of the Art Practices**	**[5 Hrs]**
	Multi Modal Transportation, Ro-Ro vessels Custom Formalities, Dedicated freight Corridor, Case Studies.	
	Site Visits (subject to obtaining approvals/permissions from concern authorities): - Mumbai Port/ JNPT , CWPRS, etc.	

References

1. Muir Wood, A.M., and Fleming. C.A., "Coastal Hydraulics Sea and Inland Port Structures", 1st Edition, Hallstead Press, 2002.
2. Ozha & Ozha, "Dock and Harbour Engineering", 1 st Edition, Charotar Books, Anand., 1990
3. S. Seetharaman, "Construction Engineering and Management", 4th Edition, Umesh publications, New Delhi, 1999.
4. Richand L. Silister, "Coastal Engineering Volume I & II, Elsevier Publishers, 2000.
5. Per Brunn, "Port Engineering", 1st Edition, Gulf Publishing Company, 2000

CTE(PPE)-23005 Airport Infrastructure Planning and Design	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/ week	**T1 and T2 -** 20 marks each
Tutorial: -	**End Sem. Exam.** - 60 marks

Course Outcomes: At the end of the course, the students is able to:
CO 1: Analyse the requirement of airport layout with respect to international regulation
CO 2: Design Airport Pavement, Taxiway, and Apron
CO 3: Assess cargo handling and VTMS implementation.
CO 4: Demonstrate visual aid required for safe landing and takeoff operation from passenger and cargo terminal
CO 5: Summarise the concept of the terminal service facility

Unit 1	**Airport Planning** **[6 Hrs]**
	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.
Unit 2	**Aircraft Characteristics** **[7 Hrs]**
	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.
Unit 3	**Air Traffic Management** **[5 Hrs]**
	Air traffic separation rules: vertical separation, flight altitudes, longitudinal separation, and lateral separation. Navigational aids: ground-based systems, satellite-based systems.
Unit 4	**Geometric Design of the Airfield** **[7 Hrs]**
	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.

Unit 5	**Structural Design of Airport Pavements [6 Hrs]**
	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.
Unit 6	**Airport Lighting, Marking, and Signage [6 Hrs]**
	Requirements of visual aids, approach lighting system configurations, visual approach slope aids, threshold lighting. Runway lighting, taxiway lighting. Runway and taxiway marking, airfield signage.
Unit 7	**Planning And Design of the Terminal Area [6 Hrs]**
	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.

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.
8. "Port Engineering", 1st Edition, Gulf Publishing Company, 2000

CTE-23003 Highway Materials	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/ week	**T1 and T2 -** 20 marks each
Tutorial: -	**End Sem. Exam.** - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Describe various pavement materials
CO 2: Compare conventional and advanced characterisation of pavement materials
CO 3: Design practical solution to Mix design of Pavement Materials
CO 4: Interpret recycled waste products

Unit 1	**Aggregate** **[8 Hrs]**
	Nature and properties, aggregate requirements, Types and processing, Aggregates for pavement base, Aggregate for bituminous mixture, Aggregate for Portland Cement Concrete, Light weight aggregate, Tests on aggregate, Specification.
Unit 2	**Bituminous Materials** **[8 Hrs]**
	Conventional and modified binders production, Types and grade, Physical and chemical properties and uses, Types of asphalt pavement construction, Principles of bituminous pavement construction, Tests on bituminous materials.
Unit 3	**Bituminous Mix design** **[8 Hrs]**
	Bituminous Mix design, Modified mixtures, Temperature susceptibility and performance. Cement /concrete based materials, Cement properties, PCC mix design and properties, Modified PCC, Mix Design behaviour, Performance, Tests on Cement and Concrete mixes. High Performance Concrete, Low shrinkage, Increased strength. Composites, Plastics and Geosynthetics: Plastics and polymerization process, Properties, Durability and Chemical composition, Reinforced Polymer Composites, Geosynthetics, Dry Powdered Polymers, Enzymes.
Unit 4	**Reclaimed/Recycled Waste Products** **[8 Hrs]**
	Reclaimed Materials, Waste products in civil engineering applications, Effect of waste products on materials, Structure and properties, self-healing and smart materials, Locally available materials.

References

1. P. T. Sherwood, Alternative Materials in Road Construction, Thomas Telford Publication, London, 1997.
2. Koerner, R. M. Designing with Geosynthetics, Prentice Hall, Englewood Cliffs, New Jersey, U.S.A.
3. Shan Somayaji, Civil Engineering Materials, second edition, Prentice Hall Inc., 2001.

CTE-23004 Highway Geotechnology	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/ week	**T1 and T2 -** 20 marks each
Tutorial: -	**End Sem. Exam.** - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Identify the soil type of soil from a job site or in a professional setting, determine the soil's properties based on type and evaluate design decisions.
CO 2: Analyze the strength, stability of soil for embankments/cuts and pavements.
CO 3: Evaluate and design the slopes, drainage and retaining structures.
CO 4: Compare and apply different rock mass classification schemes.
CO 5: Plan and execute geo-investigations, designs, construction, monitoring, and maintenance of tunnels and large underground structures.

Unit 1	**Classification of Soil**	**[6 Hrs]**
	Understanding the significance of soil classification in the context of transportation engineering. Particle size classification, HRB classification, Group Index Method, USCS and ISCS Classification	
Unit 2	**Highway Drainage**	**[6 Hrs]**
	Introduction and importance of highway drainage system. Subsoil drainage techniques tailored for highway engineering, including design considerations for filters and perforated pipe drainage. Methods of drainage for roads: surface and subsurface drainage systems. The specific application of subsoil drainage in highways, runways, and railways.	
Unit 3	**Compaction**	**[6 Hrs]**
	Importance of compaction for different transportation infrastructure. Mechanics of compaction. Lab tests, field tests, and compaction equipment based on the type of soil and field requirements. Quality control and measurement techniques for achieving optimal compaction in transportation engineering. Behavior of compacted geomaterials.	
Unit 4	**Shear Strength**	**[6 Hrs]**
	Introduction, Stress at a point, Mohr-Coulomb Failure Criteria, Measurement of Shear Strength, Shear strength of clay and sands, Drainage conditions and shear strength parameters, Stress paths, Pore water pressure and Elastic properties of soils.	
Unit 5	**Stability Analysis of Slopes**	**[6 Hrs]**
	Introduction, Slope stability for transportation infrastructures, Definitions of factor of safety, Infinite slopes and translational slides, Finite slopes – Forms of slip surface, Limiting Equilibrium method and critical stages in stability, Stability of Finite slopes, Taylors Stability Number.	

Unit 6	**Geotechnical Aspects in Pavement** **[6 Hrs]**
	Pavement system and typical pavement types; Introduction to flexible and rigid pavement, Soil stabilization and ground improvement, Geotechnical issues in pavement design and performance. Introduction to foundations for different substructures, General requirements of Foundations, Location and Depth of Foundation, Bearing capacity and settlement of Shallow foundations, Allowable bearing pressure. Uses of piles, types of piles, Driven piles and bored cast in-situ piles, Pile load carrying capacities, Dynamic piles formulae
Unit 7	**Rock Mechanics and Tunnel Engineering** **[6 Hrs]**
	Fundamental of rock Mechanics; Rock Properties; Rock Mass Classification Systems, Comparison of Rock Mass Classification Schemes, RQD index as a qualitative description of the rock mass, limitations and advantages. Geo-investigation, design approaches, construction, monitoring, and maintenance of tunnels and large underground structures. Types and purpose of tunnels; factors affecting choice of excavation technique; Methods – soft ground tunneling, hard rock tunneling, shallow tunneling, deep tunneling; Shallow tunnels – cut and cover, cover and cut, pipe jacking, jacked box excavation techniques, methods of muck disposal, supporting, problems encountered in tunneling and remedial measures.

References

1. Ranjan, G., & Rao, A. S. R. (2011). Basic and applied soil mechanics. New Age International.
2. Das, B. M., & Sivakugan, N. (2017). Fundamentals of geotechnical engineering. Cengage Learning.
3. Das, B. M. (2021). Principles of geotechnical engineering. Cengage learning.
4. Hudson, J. A., & Harrison, J. P. (2000). Engineering rock mechanics: an introduction to the principles. Elsevier.
5. Jaeger, J. C., Cook, N. G., & Zimmerman, R. (2009). Fundamentals of rock mechanics. John Wiley & Sons.
6. Chapman, D. N., Metje, N., & Stark, A. (2017). Introduction to tunnel construction. CRC Press.
7. Kuesel, T. R., King, E. H., & Bickel, J. O. (2012). Tunnel engineering handbook. Springer Science & Business Media.
8. Aydan, Ö. (2019). Rock mechanics and rock engineering: Volume 1: Fundamentals of rock mechanics. CRC Press.

CTE-23006 Transportation Engineering Lab Practice- I	
Teaching Scheme	**Examination Scheme**
Practical: 4 Hrs/ week	**End Sem. Exam.** - 100 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Analyze traffic data for traffic stream parameters
CO 2: Determine the capacity of midblock section
CO 3: Determine the capacity of intersection
CO 4: Create database and perform descriptive and inferential analysis

Course Content

Students have to perform following practical's

Mandatory

1. Space mean speed data analysis
2. Capacity analysis of urban highway using Greenshield's model
3. Capacity analysis of Signalized Intersection as per Indo-HCM (2017)

Perform any five.

1. Speed data analysis using Geotracker.
2. Capacity analysis of Roundabout as per Indo-HCM (2017)
3. Signal Design by Websters Method or Indo-HCM (2017)
4. Origin-Destination Studies
5. Home interview Survey
6. Moving Observer Method
7. Headway analysis

References

1. L. R Kadiyali. Traffic Engineering and Transportation Planning. Khanna Publishers, New Delhi, 2008.
2. May, Adolf Darlington. Traffic Flow Fundamentals,1990.
3. Indian Highway Capacity Manual (Indo-HCM), 2017
4. Relevant IRC codes

CTE-23007 Transportation Engineering Lab Practice- II	
Teaching Scheme	**Examination Scheme**
Practical: 2 Hrs/week	**End Sem. Exam.** - 100 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Apply relevant national and international codes for performing new experiments in Transportation laboratory
CO 2: Develop skills in performing experiments related to Transportation engineering and correlate with the quality standards.
CO 3: Exercise hands on experience to develop higher level motor skills
CO 4: Prepare practical and site visit report for various assigned activities

Course Content

A. Student will perform various sets of experiments in the Transportation laboratory as decided by the Laboratory In-charge and write a test report as a part of Laboratory work.

Tests on Soils: Density of soil, CBR, Determination of Field CBR using Dynamic Cone Penetrometer

Tests on Aggregate: gradation, shape tests, specific gravity, water absorption, aggregate crushing value, Los Angeles abrasion value, aggregate impact value.

Tests on Bitumen: penetration, viscosity by Brookfield Rotational Viscometer, flash and fire point, ductility and elastic recovery, softening point, specific gravity, Ageing of Bitumen: Rolling Thin Film Oven Test (Short Term) and Pressure Ageing Vessel (Long Term), Multiple Stress Creep and Recovery test using Dynamic Shear Rheometer, Linear Amplitude Sweep (LAS) test.

Tests on Bituminous Mixes: Marshall mix design, Bitumen content determination using centrifuge extractor.

Non-Destructive Tests: Benkelman Beam, Bump Indicator

B. Field visits for studying Transportation Engineering

C. Students will carry out various assignments related to the courses taught in this semester given by the faculty teaching courses.

References

1. Highway Material Testing Laboratory Manual by Khanna S. K., Justo, C.E.G and Veeraraghavan, A., Nem Chand & Bros.
2. Various IRC, ASTM and AASTHO Codes

CTE-23008 Seminar	
Teaching Scheme	**Examination Scheme**
Practical: 2 Hrs/ week	**End Sem. Exam.** - 100 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Identify a topic for study and carry out literature survey
CO 2: Write a technical report related to selected topic
CO 3: Present outcome of the study with the help of presentation

Course Contents

Selection of Topic:

- Select a topic relevant to the stream of study with content suitable for M. Tech. level presentation. For selection topics refer to internationally reputed journals. The primary reference should be published during the last two or three years.
- Some of the journals/publications suitable for reference are: ASCE/Springer/Science Direct journals in the areas of Transportation Engineering and any other related domain
- Get the topic approved by the seminar guide well in advance.

Preparation of Presentation and Report:

- In slides, list out key points only. You may include figures, charts, equations, tables etc. but not running paragraphs. The font size used should be at least 20.
- Figures should be very clear and possibly drawn by you using suitable software tools.
- A report on the seminar should be prepared which should contain the following.
  - Title of the seminar.
  - Name and other details of presenter and the guide.
  - Abstract of the topic.
  - Contents such as Introduction, Theory to elaborate the concept, Implementation if carried out by the presenter, Comparison with other relevant techniques, Conclusion, etc.
  - List of references strictly in ASCE format.

Oral Presentation:

- Student needs to orally present the topic for 15-20 minutes with good voice projection and with modest pace.

Answering Queries:

- Student needs to answer queries raised by the audience and evaluators.

Semester II

CTE(PE)-23007 Sustainable Construction Engineering	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/ week	**T1 and T2 -** 20 marks each
	End Sem. Exam. - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Identify various concepts of sustainable construction
CO 2: Apply sustainability to project planning
CO 3: Choose appropriate sustainable materials and renewable energy techniques for civil engineering projects
CO 4: Demonstrate the knowledge of the available building codes and standards

Unit 1	**[8 Hrs]**
	Sustainability and Sustainable Development. Introduction to course. Introduction to sustainable development Concepts and Theory. Definitions and Prospective on sustainability, Theory and background to sustainable construction planning. The Three E's. Environment, Economics, and Ethics. Ecology of sustainable developments.
Unit 2	**[8 Hrs]**
	Sustainable Construction Planning. Introduction to Sustainable construction. Principles of sustainability. Major Environmental challenges, Global Warming. Introduction to Green Buildings Building energy system. Strategies, Energy conservation in buildings. Energy Efficient projects. HVAC Systems. Water Conservation in buildings. Rainwater harvesting and management, Water Cycle strategies.
Unit 3	**[8 Hrs]**
	Green Buildings Introduction, Green construction, Site selection for Green Construction, Design Considerations, Objectives of Green building movement. Green construction materials and resources. Material Selection Strategies. Eco-friendly Materials, Recyclable and Reusable Materials. Embodied Energy in Materials.
Unit 4	**[8 Hrs]**
	Green Building Codes and Specifications. Introduction. Green building Codes and Standards. LEED Credits, IGBC. International Construction Codes, Carbon accounting, Green building Specifications.

References

1. Green Building Design and Delivery, 2nd Edition, John Wiley, Hoboken -New Jersey.
2. Energy Efficient Buildings in India. Ed. Mujumdar Mili. TERI PRESS.
3. Energy efficient buildings in India. Case Studies by Teri. Video Cassettes, ds.
4. Climate Responsive Architecture. Krishna Arvind.
5. Energy Management Handbook, Steve Doty and Wayne C. Turner, 8th edition.

CTE(PE)-23008 GIS and Remote Sensing for Transportation	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/ week	**T1 and T2 -** 20 marks each
	End Sem. Exam. - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Comprehend the basics about the remote sensing, GIS techniques and GPS systems.
CO 2: Conduct remote sensing data acquisition, data processing and their interpretation for practical applications.
CO 3: Choose appropriate sustainable materials and renewable energy techniques for civil engineering projects
CO 4: Analyse and interpret data in GIS environment, development of DTM and able to make network analysis to solve critical transportation problems.
CO 5: Evaluate the RS, GIS and GPS technological development in the area of Civil Engineering.

Unit 1	**Introduction To Geoinformatics** **[6Hrs]**
	Concepts and fundamentals, energy sources, energy interactions, ideal and real remote sensing systems, fundamentals of aerial photo interpretation, keys, Data acquisition, various remote sensing platforms, Basic concepts of GIS & GPS, Digital image processing.
Unit 2	**Geographical Information System** **[6 Hrs]**
	Structure of GIS: Cartography, Geographic mapping process, transformations, map projections, Geographic Data Representation, Storage, Quality and Standards, database management systems, Raster data representation, Vector data representation, Assessment of data quality, Managing data errors, Geographic data standards.
Unit 3	**Data Handling in GIS** **[6 Hrs]**
	GIS Data Processing, Analysis and Modeling: Raster based GIS data processing – Vector based GIS data processing – Queries – Spatial analysis – Descriptive statistics – Spatial autocorrelation– Quadrant counts, and nearest neighbour analysis – Network analysis.
Unit 4	**Network and Dynamic Segmentation** **[6 Hrs]**
	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.

Unit 5	**Global Positioning System [6 Hrs]**
	GPS: Basic concepts, components, factors affecting, GPS setup, accessories, segments- satellites & receivers, Navigation System, GPS Data Collection Methods, Absolute and Differential Positioning, Errors in GPS observations and their correction, Contribution of different errors in GPS observations, GPS applications, Case studies.
Unit 6	**Applications [6Hrs]**
	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.

References

1. Lo, C.P. & Yeung A.K.W., Concepts and Techniques of Geographic Information Systems, Prentice Hall of India, New Delhi, 2002.
2. Kang-Tusang Chang, Introduction to Geographic Information Systems, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2002.
3. Anji Reddy, M., Remote Sensing and Geographical Information Systems, B.S. Publications, Hyderabad, 2001.
4. Burrough, P.A., Principles of Geographical Information Systems, Oxford Publication,1998.
5. Clarke, K., Getting Started with Geographic Information Systems, Prentice Hall, New Jersy, 2001.
6. De Mers, M.N., Fundamentals of Geographic information Systems, John Wiley & Sons, New York, 2000.
7. Kennedy M., The Global Positioning System & GIS: An Introduction, Ann Arbor Press,1996.

CTE(PE)-23009 Pavement Construction and Evaluation	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/ week	**T1 and T2 -** 20 marks each
	End Sem. Exam. - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Select appropriate earth moving and compaction equipment depending upon the requirement.
CO 2: Prepare quality assurance and quality control plans in an attempt to construct better performing pavements.
CO 3: Evaluate the pavements based on the functional characteristics.
CO 4: Evaluate the pavements based on the structural characteristics.
CO 5: Select maintenance technique depending upon the pavement condition.

Unit 1	**Highway Construction Equipment**	**[6Hrs]**
	Applications and safety aspects of earth moving equipment's, compaction equipment's, road making equipment's, concreting equipment's and paving equipments, Hot mix plants, ready mix plants	
Unit 2	**Pavement Construction**	**[7 Hrs]**
	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.	
Unit 3	**Functional Evaluation of Pavements**	**[7 Hrs]**
	Introduction, factors affecting pavement deterioration, functional condition evaluation techniques, roughness measurements, Identification of uniform sections, serviceability concepts, visual and ride rating techniques.	
Unit 4	**Structural Evaluation of Pavements**	**[6 Hrs]**
	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.	
Unit 5	**Pavement Maintenance**	**[6 Hrs]**
	Routine maintenance, periodic maintenance, special repairs, responsive maintenance programme, rehabilitation and reconstruction, treatment strategies and selection criteria.	

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.

CTE(PE)-23010 Rail and Metro Construction	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/ week	**T1 and T2 -** 20 marks each
	End Sem. Exam. - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Understand functioning of various track elements in Railway and Metros.
CO 2: Acquire and understand the necessity of metro system for urban transport and the differences between various urban transport system.
CO 3: Understand cost effectiveness of various urban transport systems.
CO 4: Understand integrated operation of metro system.

Unit 1	**[6Hrs]**
	Origin of Railways, Definition/uniqueness of railways, gauge of railway track, over view of railway systems of different countries, Basic track structure Formation, unconventional railways, atmospheric railway, mountain railways, rack railways etc. Basic track structure – Formation, Maintenance and renewal of track – (in brief) manual and mechanical maintenance and renewal.
Unit 2	**[7 Hrs]**
	Turnouts and Crossings – Components constituting turnouts and crossings, Diamond crossings; Slip points, operation of turnouts mechanical & electrical, locking of turnouts, Curved Track – classification of curves, measurement of radius, movement of vehicle on curves, speed on curves, check rails, gauge widening on curves. Gradients / Vertical Curves.
Unit 3	**[7 Hrs]**
	Passenger carrying vehicles (Coaches), development of coaches, 4 wheeled coaches, 6 wheeled coaches, bogie coaches, categories of coaches, Pullman coaches, special coaches in very brief, Goods carrying vehicles, Introduction of maintenance manuals of various types of rolling stock.
Unit 4	**[6 Hrs]**
	Rail Wheel Interaction, Track elements, Flat Bottom Rail, Bull Head Rail, Cast Iron Chair, Rail Screws, Base Plate, Insulating Pad, Modified Loose Jaw, Fish Plated Joint, Insulated Joint Sleepers - Wooden, Steel Trough, Cast Iron Pot, Twin Block and Mono Block Pre-Stressed Concrete Sleepers.
Unit 5	**[6 Hrs]**
	Origin of Metro Rail System, Overview of World Metro Systems, Metro Planning and Selection, Metro Construction Metro Track, Introduction of metro act, Report of Ministry of Urban Development on standardization of metro system. Metro Operations, Metro Depots, Metro Maintenance, Metro Station Management, Passenger Information System.

References

1. Indian Railways Permanent Way Manual Published by Indian Railways corrected upto ACS-4, June 2020.
2. Notes on Curves for Railways by Prof V B Sood _ Indian Railways Institute of Civil Engineering Pune.
3. Ponnuswamy, Bridge Engineering, Delhi.
4. Metro Act _ Government of India – 2002
5. Detailed Project Reports of Various Metro Projects in India – By Delhi Metro Rail Corporation.
6. Manual of Specifications and Standards – Hyderabad Metro Government of Andhra

CTE(PE)-23011 Freight Transportation Planning and Logistics	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/ week	**T1 and T2 -** 20 marks each
	End Sem. Exam. - 60 marks

Course Outcomes: At the end of the course, the students is able to:
CO 1: Demonstrate the knowledge of various concepts of freight transportation planning.
CO 2: Minimize cost network flow
CO 3: Optimize shipment size

Unit 1	**Introduction to freight models; interregional freight demand models [8 Hrs]**
	Gravity model, Input output (IO) model, Spatial general equilibrium model (SGEM); Freight generation and freight trip generation models.
Unit 2	**Introduction to network flow [8 Hrs]**
	Network flow representation, shortest path algorithm, Assignment Problem, Transportation Problem, Minimum spanning tree, Minimum cost network flow problem, Network simplex method;
Unit 3	**Distribution structure [8 Hrs]**
	Micro-level distribution structure, Logistics costs, Drivers of distribution structure, Micro-level normative models, Warehouse location; Inventory theory and freight transport modeling: the economic order quantity (EQQ) model, Optimal shipment size.
Unit 4	**Urban freight models [8 Hrs]**
	Push models, Pull models; Vehicle routing problem; Fleet size optimization; Urban logistics: parcel delivery, e-commerce, food delivery; Freight consolidation centers; Humanitarian logistics during disasters.

References

1. L. Tavasszy and G. De Jong, Modeling Freight Tranport, Elsevier, 2014
2. M. Browne, S. Behrends, Woxenius, G. Giuiano, and J, Holguin-Veras, Urban Logistics, Kogan Page, 2019
3. E. Taniguchi and R. G. Thompson, City Logistics, Emerald Group Publishing, Limited, 2001

CTE(PE)-23012 Intelligent Transportation Systems	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/ week	**T1 and T2 -** 20 marks each
	End Sem. Exam. - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Demonstrate the fundamentals of ITS
CO 2: Identify the ITS functional areas
CO 3: Apply the knowledge of vehicle safety
CO 4: Facilitate the ITS implementation in developing countries

Unit 1	**Introduction to Intelligent Transportation Systems (ITS) [6 Hrs]**
	Definition of ITS and Identification of ITS Objectives, Historical Background, Benefits of ITS - ITS Data collection techniques – Detectors, Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), Geographic Information Systems (GIS), video data collection.
Unit 2	**Telecommunications in ITS [7 Hrs]**
	Importance of telecommunications in the ITS system, Information Management, Traffic Management Centres (TMC). Vehicle – Roadside communication – Vehicle Positioning System
Unit 3	**ITS functional areas [7 Hrs]**
	Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Commercial Vehicle Operations (CVO), Advanced Vehicle Control Systems (AVCS), Advanced Public Transportation Systems (APTS), Advanced Rural Transportation Systems (ARTS).
Unit 4	**ITS User Needs and Services [6 Hrs]**
	Travel and Traffic management, Public Transportation Management, Electronic Payment, Commercial Vehicle Operations, Emergency Management, Advanced Vehicle safety systems, Information Management.
Unit 5	**Automated Highway Systems [6 Hrs]**
	Vehicles in Platoons – Integration of Automated Highway Systems. ITS Programs in the World – Overview of ITS implementations in developed countries, ITS in developing countries.

References

1. Pradip Kumar Sarkar and Amit Kumar Jain; Intelligent Transportation Systems' PHI Learning, 2018
2. Mashrur Chowdhury and Adel W. Sadek, Fundamentals of Intelligent Transportation Systems Planning, Artech House Publishers, 2003
3. Relevant IRC codes, publisher IRC

CTE(PE)-23014 Artificial Intelligence and Machine Learning Applications for Transportation	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/ week	**T1 and T2 -** 20 marks each
	End Sem. Exam. - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Define data mining concepts and data pre-processing techniques
CO 2: Analyze components of Instance-Based Learning, explaining KNN and variants
CO 3: Implement Decision Tree construction and Support Vector Machines, with a focus on multiclass classification
CO 4: Assess Outlier Mining techniques, differentiating between statistic-based, distance-based, and density-based methods
CO 5: Design Ensemble Learning methods (Bagging, Boosting, etc.) and propose strategies for handling class-imbalanced data

Unit 1	**Introduction to data mining**	**[6 Hrs]**
	What is data mining, Data mining functionality, Data Mining Techniques	
Unit 2	**Data pre-processing**	**[7 Hrs]**
	techniques of preprocessing data, including data cleansing, Data integration, data reduction, and transformation.	
Unit 3	**Instance based learning**	**[7 Hrs]**
	Overview of IBL, three components of KNN and two Variants of kNN	
Unit 4	**Decision trees and Support vector machine**	**[6 Hrs]**
	Decision tree representation, Construct Decision Tree, Overfitting and Tree Pruning, Pros and Cons of DTs, Decision Tree Representation Linear Support Vector Machine and non-Linear Support Vector Machine, multiclass classification, support vector regression.	
Unit 5	**Outlier mining**	**[6 Hrs]**
	Background of Outlier Detection**,** three techniques to detect outliers, including statistic-based method, distance-based method, and density-based method.	
Unit 6	**Ensemble leaning**	**[6 Hrs]**
	General Idea of Ensemble Methods, several classical ensemble methods, including Bagging, boosting, Cross validated Committees, and random forests. Generation of members and combining schemes in general. Besides, techniques to improve the classification performance for class-imbalanced data.	

References

1. Jiawei Han, Micheline Kamber and Jian Pei, Data Mining: Concepts and Techniques, Morgan Kaufmann, 3rd edition, 2011.
2. Ian H.Witten, Eibe Frank, Data Mining: Practical Machine Learning Tools and Techniques with Java Implementations, San Francisco: Morgan Kaufmann Publishers, 3rd ed. 2011.
3. Charu C. Aggarwal, Data Mining: The Textbook, Springer, May 2015.
4. Pang-Ning Tan, Michael Steinbach, Vipin Kumar, Introduction to Data Mining, Pearson, 1st Edition, 2005.
5. Christopher M. Bishop, Pattern recognition and machine learning, the Morgan Kaufmann series in information science and statistics, Springer Science, 2006.

CTE(PE)-23015 Traffic Flow Modelling and Simulation	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/ week	**T1 and T2 -** 20 marks each
	End Sem. Exam. - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Comprehend, represent and analyze the variation of traffic flow characteristics at microscopic and macroscopic levels using trajectory data
CO 2: Recognize various car-following theories for identifying key factors affecting driving behavior and traffic performance
CO 3: Evaluate traffic stability and efficiency for varying roadway and traffic conditions by means of design and control parameters
CO 4: Solve real world transportation problems using queuing theory
CO 5: Apply programming and simulation skillset to interpret and analyze data pertaining to traffic and transportation engineering problems

Unit 1	**Traffic Stream Characteristics** **[6Hrs]**
	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.
Unit 2	**Traffic Stream Models** **[7 Hrs]**
	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.
Unit 3	**Shockwave Analysis** **[7 Hrs]**
	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.

Unit 4	**Queuing Analysis** **[6 Hrs]**
	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.
Unit 5	**Traffic Simulation** **[6 Hrs]**
	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.

References

1. Boris S. Kerner, Introduction to Modern Traffic Flow Theory and Control, Springer; 1st Edition. Edition, 2009
2. Ni, D., Traffic Flow Theory: Characteristics, experimental methods, and numerical techniques. Butterworth-Heinemann, 2015
3. Drew, DR., Traffic flow theory and control McGraw Hill Book Company, 1976.
4. Highway Capacity Manual, Transportation Research Board, Washington, D.C., 2016.
5. May, A.D. Traffic Flow Fundamentals, Prentice Hall, 1st Edition, 1990.
6. Roger P. Roess, E. S. Prassas and W. R. McShane, Traffic Engineering, Prentice Hall, 4th edition, 2010.
7. Clifford S., E. S. Park, Laurence R. R., Transportation Statistics and Microsimulation, CRC Press, Taylor and Francis group, 2011.
8. Winnie Daamen, Christine Buisson, Serge P. Hoogendoorn, Traffic Simulation and Data: Validation Methods and Applications, CRC Press, 2014
9. Edward Chung, Andre-Gilles Dumont, Transport Simulation: Beyond Traditional Approaches, CRC Press, 2009.

CTE(PE)-23016 Sustainable Transportation	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/ week	**T1 and T2 -** 20 marks each
	End Sem. Exam. - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Explain effect of transport sector on sustainability
CO 2: Specify transport planning strategies for sustainable development
CO 3: Evaluate strategies for development of non-motorised transport
CO 4: Specify actions for planning for pedestrian and bicyclist's facilities
CO 5: Elaborate on sustainable technologies for mobility management

Unit 1	**Problem of Sustainability in Transport**	**[6Hrs]**
	Energy use in transport sector; Transport and climate change; Greenhouse gas emissions, urban air quality, Congestion, and sustainability.	
Unit 2	**Planning for Sustainability**	**[6 Hrs]**
	Urban form, Indicator based planning, landuse transportation integration, Compact City, Public Transit, TOD, NMT, First and Last Mile Connectivity.	
Unit 3	**Evaluation of Non-Motorized Transportation**	**[6 Hrs]**
	Surveys, Demand Estimation and Analysis; Crash Data, Barrier Effect; Cycling Condition Evaluation Techniques; Pedestrian Condition Evaluation Techniques; Prioritizing Improvements and Selecting Preferred Options.	
Unit 4	**Planning for Pedestrians**	**[6 Hrs]**
	Types of pedestrians and Characteristics; Pedestrian facilities and planning; Pedestrian standards and improvements; Pedestrian facility Design, LOS; Pedestrian safety programs	
Unit 5	**Planning for Bicyclists**	**[6 Hrs]**
	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.	
Unit 6	**Sustainable Policies**	**[6 Hrs]**
	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.	
Unit 7	**Sustainable Technology**	**[6 Hrs]**
	Telecommuting, Information and Communication technologies, E-commerce, Alternative Cleaner Fuels, vehicle technologies, fuel cells, Intelligent Transport Systems.	
Unit 8	**Nationally Appropriate Mitigation Actions**	**[6 Hrs]**
	Mobility Management policies, Supporting Bicycling, creating pedestrian friendly facilities, encouraging Public Transportation	

References

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.

CTE(PE)-23017 Design of Underground Structures	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/ week	**T1 and T2 -** 20 marks each
	End Sem. Exam. - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Comprehend the design aspects of various underground structures in soil and rockmass
CO 2: Identify the excavation methods for construction of underground structures in different ground conditions
CO 3: Analyze the underground structures in rock and soil using elastic and elastoplastic solutions
CO 4: Appraise the underground structure using empirical, observational, analytical and numerical approaches
CO 5: Design the support and safety system for underground structures

Unit 1	**Introduction**	**[6Hrs]**
	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	
Unit 2	**Excavation Method and Machinery**	**[6 Hrs]**
	Drilling and Blasting for Underground and Open Excavations. 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.	
Unit 3	**Analysis And Design of Underground Openings**	**[6 Hrs]**
	Analysis of Underground openings, stresses around different shapes, initial state of stresses, Closed form solutions, 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.	
Unit 4	**Design of Support System**	**[6 Hrs]**
	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	
Unit 5	**Tunnel Health and Safety Issues**	**[6 Hrs]**
	Construction methods, Ventilation, De-watering, Control and monitoring system: services, operations and maintenance. Surveillance and control system for highway tunnels. Tunnel finish, Rehabilitation: Inspection methods, Repairs, Tunnel construction contracting.	

References

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

CTE(PE)-23018 Public Transport Planning	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/ week	**T1 and T2 -** 20 marks each
	End Sem. Exam. - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
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 timetable, vehicle and crew schedules
CO 5: Carry out performance evaluation of transit operations

Unit 1	**Transit Systems**	**[6Hrs]**
	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.	
Unit 2	**Estimation of Transit Demand**	**[6 Hrs]**
	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.	
Unit 3	**Transit Design**	**[6 Hrs]**
	Frequency & headway determination methods – Rail operation design – Bus operation design – Way capacity & Station capacity –Transit level of service	
Unit 4	**Transit Route Network Planning**	**[6 Hrs]**
	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.	
Unit 5	**Scheduling**	**[6 Hrs]**
	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	
Unit 6	**Mass Transit Corridor Identification & Planning**	**[6 Hrs]**
	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.	

Unit 7	Transit Terminals and Performance Evaluation [6 Hrs]
	Performance Evaluation – Efficiency, Capacity, Productivity and Utilisation – Performance Evaluation Techniques and Application – System Network Performance – Transit Terminal Planning and Design.

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.

CTE(PE)-23019 Highway Financing and Policy Analysis	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/ week	**T1 and T2 -** 20 marks each
	End Sem. Exam. - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Demonstrate the knowledge of concepts in transportation economics.
CO 2: Apply demand and supply side concepts to transport policy and planning issues.
CO 3: Calculate various transport costs
CO 4: Compare mutually exclusive projects and select the most attractive one
CO 5: Appraise various methods for funding and financing of transportation projects

Scope of Transportation Economics, economic development and urban development. Economic theory, demand and supply issues in transportation sector, demand - supply equilibrium, cost and pricing of transport, law of diminishing returns, elasticity and consumer surplus, costs, pricing and subsidy policies, Demand forecasting methods, price elasticity of demand, Main causes of traffic congestion, congestion pricing, road space rationing, and capacity expansion, Supply of transport services, development of systems supply function; Command and control type of regulation, fiscal measures such as road pricing and environmental taxation, safety and economic regulations in the context of transport services provided by public, issues of social, geographical and temporal equity. Direct and external costs of transport generalized costs, social aspects of transport, joint and common costs of infrastructure, average and marginal cost principle, short-term and long-term costs of supply, congestion costs, external costs, Road User Cost and it's components; Pricing principles efficient pricing, cost complexities and cost recovery, peak load pricing, second-best pricing, Transport subsidies, price discrimination. evaluation of alternatives, analysis techniques, social and financial benefits, Internal Rate of return method for economic and financial viability, valuation of time, measures of land value and consumer benefits from transportation projects, prioritization of projects, multi-criteria decision assessment, Construction of new infrastructure: investment analysis, Methods for raising funds for maintenance, improvement and expansion of transportation networks, taxation and user fee, financing through loans, bonds, PPPs/PSP and concessions.

References

1. Mccarthy, P.S., "Transportation Economics- Theory and Practice: A Case Study Approach", Blackwell Publishing
2. E. Quinet, R. Vickerman and R.W. Vickerman, "Principles of Transport Economics", Edward Elgare Publishing.
3. Button, K.J., "Transportation Economics", 3rd Ed., Edward Elgare Publishing

LL Liberal Learning	
Teaching Scheme	**Examination Scheme**
Lectures: 1 Hrs/ week	**T1 and T2 -** 20 marks each
	End Sem. Exam. - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Develop capacity to understand multidisciplinary sciences in a friendly manner.
CO 2: Create openness to diversity.
CO 3: Acquire ability to lead and examine life and value the need for life learning.

Student will be able to choose and enhance practical learning and application in the subject of his/her choice. One credit course spread over the semester to enhance practical learning and application.

- Dance
- Film Appreciation
- Music Vocal
- Painting
- Agriculture
- Business
- Clay Art & Pottery
- Corporate Culture
- Defense
- French
- Geography
- Holistic Health
- Modern Film Making
- Music (Instrumental)
- Photography
- Political Science
- Music (Vocal)
- Wood and Metal Art
- Japanese

ML-23001 Research Methodology and Intellectual Property Rights	
Teaching Scheme	**Examination Scheme**
Lectures: 2 Hrs/ week	**T1 and T2 -** 20 marks each
	End Sem. Exam. - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Understand research problem formulation and approaches of investigation of solutions for research problems
CO 2: Learn ethical practices to be followed in research and apply research methodology in case studies and acquire skills required for presentation of research outcomes
CO 3: Discover how IPR is regarded as a source of national wealth and mark of an economic leadership in context of global market scenario
CO 4: Summarize that it is an incentive for further research work and investment in R & D, leading to creation of new and better products and generation of economic and social benefits

Course Contents

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations.

Effective literature studies approaches, analysis, Use Design of Experiments /Taguchi Method to plan a set of experiments or simulations or build prototype, Analyze your results and draw conclusions or Build Prototype, Test and Redesign

Plagiarism, Research ethics, Effective technical writing, how to write report, Paper, Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee Introduction to the concepts Property and Intellectual Property, Nature and Importance of Intellectual Property Rights, Objectives and Importance of understanding Intellectual Property Rights

Understanding the types of Intellectual Property Rights: -Patents-Indian Patent Office and its Administration, Administration of Patent System – Patenting under Indian Patent Act, Patent Rights and its Scope, Licensing and transfer of technology, Patent information and database. Provisional and Non-Provisional Patent Application and Specification, Plant Patenting, Idea Patenting, Integrated Circuits, Industrial Designs, Trademarks (Registered and unregistered trademarks), Copyrights, Traditional Knowledge, Geographical Indications, Trade Secrets, Case Studies

New Developments in IPR, Process of Patenting and Development: technological research, innovation, patenting, development, International Scenario: WIPO, TRIPs, Patenting under PCT

Reference Books

1. Aswani Kumar Bansal: Law of Trademarks in India
2. B L Wadehra: Law Relating to Patents, Trademarks, Copyright, Designs and Geographical Indications.
3. G.V.G Krishnamurthy: The Law of Trademarks, Copyright, Patents and Design.
4. Satyawrat Ponkse: The Management of Intellectual Property.
5. S K Roy Chaudhary & H K Saharay: The Law of Trademarks, Copyright, Patents
6. Intellectual Property Rights under WTO by T. Ramappa, S. Chand.
7. Manual of Patent Office Practice and Procedure
8. WIPO: WIPO Guide To Using Patent Information
9. Resisting Intellectual Property by Halbert, Taylor & Francis
10. Industrial Design by Mayall, Mc Graw Hill
11. Product Design by Niebel, Mc Graw Hill
12. Introduction to Design by Asimov, Prentice Hall
13. Intellectual Property in New Technological Age by Robert P. Merges, Peter S. Menell, Mark A. Lemley
14. Stuart Melville and Wayne Goddard, "Research methodology: An Introduction for Science and Engineering Students", Juta and Company Ltd.
15. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction", Juta and Company Ltd, 2004
16. Ranjit Kumar, "Research Methodology: A Step-by-Step Guide for Beginners", SAGE Publications, 2 nd edition, 2005

CTE-23009 Highway Structures	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/ week	**T1 and T2 -** 20 marks each
	End Sem. Exam. - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Demonstrate the knowledge of highway structures and its various components.
CO 2: Demonstrate the knowledge of various techniques in highway structures.
CO 3: Select and apply appropriate foundations and highway structures.
CO 4: Determine design flood discharge, afflux, linear waterway of bridges and scour depth.
CO 5: Select suitable grade separators, river training works and rigid or flexible pavements.

Unit 1	**[7 Hrs]**
	Introduction, Investigation for Bridges and Culverts, Investigations for Important Bridges, Design Flood Discharge for bridges, Linear Waterway of Bridges.
Unit 2	**[6 Hrs]**
	Choice of Foundation for Piers and Abutments, Types of Bridges and Loading Standards, Setting out for Piers and Abutments, Open Foundation, Pile Foundations, Well Foundation- Case Studies.
Unit 3	**[7 Hrs]**
	Piers and Abutments, Superstructure- Design Aspects, Superstructure- Construction, Inspection of Bridges, Maintenance of Bridges- substructure, Maintenance of superstructure – Girders
Unit 4	**[6 Hrs]**
	Rebuilding of Bridges, Construction Management, Grade Separators, River Training and Protection Works, Embankments, Tests on Compaction, Approaches, Layers in Flexible and Rigid pavements, Quality Control Aspects
Unit 5	**[6 Hrs]**
	Retaining walls, small box culverts, large pipe headwalls, high-mast light poles, ITS devices, reinforced soil slopes, sound abutment walls, overhead signs and traffic signals

References

1. S. Ponnuswamy, Bridge Engineering, McGraw Hill Education.
2. Das, P.C., 'Management of highway structures', Thomas Telford Publishing, London

CTE-23010 Analysis and Design of Pavements	
Teaching Scheme	**Examination Scheme**
Lectures: 4 Hrs/ week	**T1 and T2 -** 20 marks each
	End Sem. Exam. - 60 marks

Course Outcomes: At the end of the course, the students is able to:
CO 1: Comprehend the behaviour of pavement based on material characteristics.
CO 2: Analyse the pavement by considering various input parameters appropriately.
CO 3: Select the rational method of pavement design.
CO 4: Identify the design criteria based on the major failure patterns of pavement.
CO 5: Design the pavement with the guidelines given by IRC, AASHTO, and PCA.

Unit 1	**Introduction**	**[8 Hrs]**
	Components of pavement structure, importance of sub grade soil properties on pavement performance. Functions of subgrade, subbase, base course and wearing course.	
Unit 2	**Stresses in Pavements**	**[9 Hrs]**
	Flexible pavements - Stresses in homogeneous masses and layered systems, deflections, shear failures, equivalent wheel and axle loads; Rigid pavements - Westergaard's and Thomlinson's analysis of warping stresses, Combination of stresses due to different causes, Effect of temperature variation on Rigid Pavements	
Unit 3	**Design Elements of Flexible Pavements**	**[9 Hrs]**
	Loading characteristics-static, impact and repeated loads, effects of dual wheels and tandem axles, area of contact and tyre pressure, modulus or CBR value of different layers, equivalent single wheel load, equivalent stress and equivalent deflection criterion, equivalent wheel load factors, climatic and environmental factors.	
Unit 4	**Design Methods for Flexible Pavements**	**[9 Hrs]**
	California bearing ratio (CBR) adopted in various countries, IRC: 37-2018, AASHTO Design Guide, Triaxial method, Boussinesq's and Bunnister's analysis, Pavement designing software (IITPAVE, KENPAVE, MICH-PAVE); Design of flexible pavements for low volume roads	
Unit 5	**Rigid Pavements**	**[8 Hrs]**
	Design of rigid pavement using IRC: 58-2015 and AASHTO guidelines, Wheel load stresses, Role of modulus of subgrade reaction, Westergaard's analysis, Bradbury's approach Arlington test, Pickett's corner load theory and charts for liquid, elastic and soil of finite and infinite depths of subgrade.	

Unit 6	Types of Concrete Pavements [5 Hrs]
	Roller Compacted Concrete Pavement, Plain Jointed Concrete Pavement, Continuously Reinforced Concrete Pavement, Prestressed concrete pavement, Design of Tie Bars and Dowel Bars, Role of Dry Lean Concrete; Rigid pavement design for low volume roads

References

1. Yoder, E.J. and Witczak, M.W., "Principles of Pavement Design 2nd Ed", John Wiley & Songs, Inc. 1975
2. O' Flaherty, A. Coleman, "Highways: the Location, Design, Construction and Maintenance of Road Pavements", 4th Ed., Elsevier 2006
3. Fwa, T.F., "The Handbook of Highway Engineering", CRC Press Taylor & Francies Group. 2006
4. Khanna, S.K. and Justo, C.E.G., "Highway Engineering Nern Chand Jain & Bros, 8th Ed. 2005
5. Papagiannakis, A.T. and Masad, E.A., "Pavement Design and Materials, John Wiley & Sons Inc. 2008
6. Yang H. Huang, " Pavement Analysis and Design" Second Edition, Pearson Education Inc.2004

CTE-23011 Road Safety and Road Safety Audit	
Teaching Scheme	**Examination Scheme**
Lectures: 3 Hrs/ week	**T1 and T2 -** 20 marks each
	End Sem. Exam. - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Define key aspects of road accidents, distinguish accidents from crashes, and recall elements of road safety plans.
CO 2: Explain the impact of human factors on road safety, analyze planning considerations, and comprehend crash reconstruction principles and statistical analysis of accidents.
CO 3: Utilize road safety engineering principles for designing safe road links and junctions, apply statistical analysis to predict accidents, and use crash data for hazard identification.
CO 4: Evaluate economic aspects of accidents, analyze road safety audits, and critically assess crash locations through diagnostic processes and data interpretation.
CO 5: Assess the effectiveness of road safety strategies, before-after methods in crash analysis, and critically evaluate statistical models related to accidents and road safety audits.

Unit 1	**Introduction** **[6Hrs]**
	Road traffic accidents scenario in India, characteristics of accidents, accident vs. crash, effect of human factors, planning for road network, land use and road environment for safety, designing for road safety - links and junctions, road safety engineering, road safety improvement strategies, elements of a road safety plan.
Unit 2	**Crash investigation and analysis** **[6 Hrs]**
	Steps in treatment of crash locations, diagnosing crash problem and solutions, accident report form, storing of data, using and interpreting crash data, identifying and prioritizing hazardous locations, condition and collision diagrams; Vulnerable Road Users: crashes related to pedestrian and bicyclists, their safety, provision for disabled; Crash reconstruction: understanding basic physics, calculation of speed for various skid, friction, drag, and acceleration scenarios.
Unit 3	**Statistical analysis of accidents** **[6 Hrs]**
	Descriptive statistics, confidence interval, hypothesis testing, models related to accident frequency, accident severity, accident duration, various methodological issues - over/under dispersion, time-varying explanatory variables, unobserved heterogeneity, endogeneity, under-reporting, spatial and temporal correlation, etc; Accident prediction model.
Unit 4	**Before -after methods in crash analysis** **[4 Hrs]**
	Before and after study, before and after study with control sites, comparative parallel study, before, during and after study, Empirical Bayes method.

Unit 5	**Economic analysis of accidents**	**[4 Hrs]**
	Accident costing-economic appraisal, EUAC, PWOC, B/C ratio, IRR, NPV.	
Unit 6	**Road Safety Auditing**	**[10 Hrs]**
	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. Road design issues in RSA's. Overview of Road Safety Hazards. Report writing including deficiency identification, corrective actions recommendations, prioritization. Structuring RSA report. Hazard Identification and Management, Risk Assessment & Prioritization of audit recommendations. Performing planning & design stage road safety audit, pre-opening & existing stage of safety audit, assessing factors responsible for deciding/ relocating the road alignment, before/ after analysis as a case study, Introduction to Construction Stage Road Safety Audits, Performing Construction Stage Safety Audits on Urban Roads, Safety at Construction Site: Safety provisions for workers at construction site, Construction Zone markings, standard barricading and work zone signage & marking plan.	

References

1. IRC SP 88- 2019 Road Safety Audit Manual (Second Revision)
2. IRC SP 55 2015 Work Zone Traffic Management
3. Highway Safety Manual by Transportation Research Board
4. Kadiyali, L.R., `Traffic Engineering and Transport Planning', Khanna Publications
5. Babkov, V.F. `Road conditions and Traffic Safety', MIR publications, - 1975.
6. K.W. Ogden, `Safer Roads – A Guide to Road Safety Engg.' Averbury Technical, Ashgate Publishing Ltd., Aldershot, England, 1996.
7. Khanna and Justo , 'Highway Engineering', Nem Chand & Brothers, Roorkee.
8. Pignataro, Louis, `Traffic Engineering - Theory and Practice', John Wiley.
9. RRL, DSIR, `Research on Road Safety', HMSO, London.
10. Papacoastas,'Introduction to Transportation Engineering' –Prentice

CTE-23012 Transportation Engineering Lab Practice- III	
Teaching Scheme	**Examination Scheme**
Lectures: 4 Hrs/ week	**End Sem. Exam.** - 100 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Demonstrate the knowledge of various software related to Transportation Engineering
CO 2: Visit projects, prepare and present technical reports
CO 3: Analyze and apply solution for complex problems using advanced software

Course Content

A. Students should carry out the following and prepare report for the same

Mandatory

1. Use of statistical software for classification, dimension reduction, and forecasting.
2. Development of basic road network in microsimulation model
3. Characterization of Mixed Traffic in microsimulation model
4. Calibration of driving behaviour parameter for Indian traffic conditions
5. Demonstration of traffic calming measures in microsimulation model
6. Evaluation of results from microsimulation model
7. Design of Rigid Pavement using MS Excel as per IRC 58 (2015)

Any Three

1. Development of signal control system in microsimulation model
2. Design of Dowel Bar using MS Excel as per IRC 58 (2015)
3. Design of Tie Bar using MS Excel as per IRC 58 (2015)
4. Use advance highway design software: Developing sight distance profile for highway alignment, Evaluating existing horizontal and vertical curves, Super elevation development, Intersection design, Interchange design.
5. Solving case study problems in travel demand modelling with the help of transportation planning and econometric packages.

B. Field visits for studying Transportation Engineering
C. Students will carry out various assignments related to the courses taught in this semester given by the faculty teaching courses

References

1. Kadiyali, L.R., `Traffic Engineering and Transport Planning', Khanna Publications
2. Indian Highway Capacity Manual, 2017.
3. VISSIM Manual
4. Relevant IRC Codes

CTE-23013 Mini Project	
Teaching Scheme	**Examination Scheme**
Lectures: 2 Hrs/ week	**Mid Sem. Exam -** 40 marks
	End Sem. Exam. - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Identify a topic for study and carry out literature survey
CO 2: Write a technical report related to selected topic
CO 3: Present outcome of the study with the help of presentation

Course content

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.

Selection of Topic:
- Select a topic relevant to the stream of study with content suitable for M. Tech. level. For selection topics refer to internationally reputed journals and find the research gap/methodology that can be replicated as mini project. The primary reference should be published during the last two or three years.
- Some of the journals/publications suitable for reference are: ASCE/Springer/Science Direct journals in the areas of Transportation Engineering and any other related domain
- Get the topic approved by the mini project guide well in advance.

Preparation of Presentation and Report:
- In slides, list out key points only. You may include figures, charts, equations, tables etc., but not running paragraphs. The font size used should be at least 20.
- Figures should be very clear and possibly drawn by you using suitable software tools.
- A report on the project should be prepared which should contain the following.
  - Title of the mini project.
  - Name and other details of presenter and the guide.
  - Abstract of the topic.
  - Contents such as Introduction, Theory to elaborate the concept, Implementation if carried out by the presenter, Comparison with other relevant techniques, Conclusion, etc.
  - List of references strictly in ASCE format.

Oral Presentation:
- Student needs to orally present the topic for 15-20 minutes with good voice projection and with modest pace.

Answering Queries:
Student needs to answer queries raised by the audience and evaluators.

Semester III

Dissertation I	
Teaching Scheme	**Examination Scheme** **Mid Sem. Exam –** 40 marks **End Sem. Exam.** - 60 marks

Course Outcomes: At the end of the course, the students will be able to:
CO 1: Identify and carry out research in key areas of Transportation Engineering
CO 2: Analyze data collected and interpret the same
CO 3: Demonstrate the evidence of understanding of the chosen topic area, and presentation of technical information.
CO 4: Use and develop written and oral presentation skills.

Course Contents

The dissertation / project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the academics and the practice.

The student should complete the following:

1. Literature survey
2. Problem Definition
3. Motivation for study and Objectives
4. Data collection / experimental work
5. Report and presentation

References

1. Various books, research papers, patents and IPRs on the topic selected for the dissertation.

Semester IV

Dissertation II	
Teaching Scheme	**Examination Scheme** **Mid. Sem. Exam –** 40 marks **End Sem. Exam.** - 60 marks

Course Outcomes: At the end of the course, the students is able to:
CO 1: Synthesize knowledge and skills previously gained and applied to in-depth study and execution of new technical problems.
CO 2: Capable of selecting from different methodologies, methods and forms of analysis suitable to research problems and justify it.
CO 3: Ability to present the findings of their technical solution in a written report.
CO 4: Develop conclusions based on the analysis which are useful to the society at large
CO 5: Present outcome of the study with the help of presentation

Course Contents

M. Tech. project is aimed at training the students to analyze independently any problem in the field of Transportation Engineering. The project may be analytical, computational, experimental or a combination of three. The project report is expected to show clarity of thoughts and expression, critical appreciation of the existing literature and analytical, experimental, computational aptitude. The student progress of the dissertation work will be evaluated in stage II by the departmental evaluation committee and final viva voce will be conducted by the external examiner.

References

1. Various books, research papers, patents and IPRs on the topic selected for the dissertation.