M.Tech.

IN

TRAFFIC AND TRANSPORTATION PLANNING

CURRICULUM AND SYLLABI

(Applicable from 2023 admission onwards)

Department of Civil Engineering
NATIONAL INSTITUTE OF TECHNOLOGY CALICUT
Kozhikode - 673601, KERALA, INDIA

The Program Educational Objectives (PEOs) of M.Tech.in Traffic and Transportation Planning

PEO1	Demonstrate advanced knowledge in Transportation Engineering, so that they can effectively compete with their contemporaries in the National / International Level.
PEO2	Exhibit strong communication, technical writing and interpersonal skills to excel in career along with passion for life-long learning.
PEO3	Execute projects with professional ethics, safety, sustainability and societal commitment.

Programme Outcomes (POs) and Programme Specific Outcomes (PSOs) of M.Tech .in Traffic and Transportation Planning

PO1	Ability to independently carry out research/investigation and development work to solve practical problems.
PO2	Ability to write and present a substantial technical report/document.
PO3	Demonstrate a degree of mastery over the area as per the specialisation of the programme.
PSO1	Apply ethical principles in discharge of their responsibilities to solve transportation problems considering economy, safety, social and environmental aspects of sustainable development.
PSO2	Ability for life-long learning of new and innovative technologies related to Transportation Engineering.

CURRICULUM

Total credits for completing M.Tech. Traffic and Transportation Planning is 75.

COURSE CATEGORIES AND CREDIT REQUIREMENTS:

The structure of M.Tech. programme shall have the following Course Categories:

Sl. No.	Course Category	Minimum Credits
1.	Program Core (PC)	23 + 35(Projects)
2.	Program Electives (PE)	15
3.	Institute Elective (IE)	2
4.	Projects	35

The effort to be put in by the student is indicated in the tables below as follows:
L: Lecture (One unit is of 50 minute duration)
T: Tutorial (One unit is of 50 minute duration)
P: Practical (One unit is of one hour duration)
O: Outside the class effort / self-study (One unit is of one hour duration)

PROGRAMME STRUCTURE

Semester I

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	CE6201E	Traffic Engineering and Management	3	0	2	7	4	PC
2.	CE6202E	Transportation Planning	3	0	0	6	3	PC
3.	CE6203E	Pavement Materials, Design and Construction	3	1	0	8	4	PC
4.	CE6291E	Pavement Engineering Laboratory and Seminar	0	0	2	1	1	PC
5.	CE6292E	Computer Applications in Transportation Engineering	0	0	2	1	1	PC
6.	CE****E	Programme Elective 1	3	0	0	6	3	PE
7.	CE****E	Programme Elective 2	3	0	0	6	3	PE
8.		Institute Elective	2	0	0	4	2	IE
		Total					**21**	**--**

Semester II

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	CE6211E	Theories of Traffic Flow	3	0	0	6	3	PC
2.	CE6212E	Transportation Data Analysis and Modelling	3	1	0	8	4	PC
3.	CE6213E	Pavement Evaluation and Management	3	0	0	6	3	PC
4.	CE****E	Programme Elective 3	3	0	0	6	3	PE
5.	CE****E	Programme Elective 4	3	0	0	6	3	PE
6.	CE****E	Programme Elective 5	3	0	0	6	3	PE
7.	CE6296E	Project: Phase I	0	0	0	6	2	PC
		Total					**21**	--

Semester III

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	CE7297E	Project: Phase II*	0	0	0	9	3	PC
2.	CE7298E	Project: Phase III	0	0	0	45	15	PC
		Total					**18**	--

* Summer Internship/Project to be carried out during the summer break.

Semester IV

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	CE7299E	Project: Phase IV	0	0	0	45	15	PC
		Total					**15**	--

List of Electives

Sl. No.	Course Code	Course Title	L	T	P	O	Credits
1.	CE6221E	Transportation Infrastructure Design	3	0	0	6	3
2.	CE6222E	Transportation Systems Management	3	0	0	6	3
3.	CE6223E	Public Transport Planning and Design	3	0	0	6	3
4.	CE6224E	Transportation and Land Use	3	0	0	6	3
5.	CE6225E	Transportation Systems and Analysis	3	0	0	6	3

Sl. No.	Course Code	Course Title	L	T	P	O	Credits
6.	CE6226E	Geographic Information System and Its Applications	3	0	0	6	3
7.	CE6227E	Highway Safety Management	3	0	0	6	3
8.	CE6228E	Highway Capacity Analysis	3	0	0	6	3
9.	CE6229E	Simulation Modelling of Transportation Systems	3	0	0	6	3
10.	CE6230E	Travel Demand Modelling	3	0	0	6	3
11.	CE6231E	Road Asset Management	3	0	0	6	3
12.	CE6232E	Transportation Economics and Appraisal	3	0	0	6	3
13.	CE6233E	Environmental Impact Assessment of Transportation Projects	3	0	0	6	3
14.	CE6234E	Highway Safety Analysis and Modelling	3	0	0	6	3
15.	CE6235E	Statistical Analysis of Transportation Data	3	0	0	6	3
16.	CE6236E	Machine Learning Applications in Transportation Engineering	3	0	0	6	3
17.	CE6237E	Freight Transport Modelling	3	0	0	6	3
18.	CE6238E	Optimization of Transportation Systems	3	0	0	6	3
19.	CE6239E	Low Volume Roads	3	0	0	6	3
20.	CE6240E	Alternative Materials and Methods for Road Construction	3	0	0	6	3

List of Institute Electives

Sl. No.	Course Code	Course Title	L	T	P	O	Credits
1.	IE6001E	Entrepreneurship Development	2	0	0	4	2
2.	MS6174E	Technical Communication and Writing	2	1	0	4	2
3.	ZZ6002E	Research Methodology	2	1	0	4	2

CE6201E TRAFFIC ENGINEERING AND MANAGEMENT

Pre-requisites: Nil

L	T	P	O	C
3	0	2	7	4

Total Lecture Sessions: 39

Course Outcomes:

CO1: Identify the influence of traffic stream components on traffic flow.
CO2: Establish the relationships between traffic stream parameters.
CO3: Conduct traffic engineering studies, analyse the data and present the results.
CO4: Design traffic and road facilities, and intersection control measures for smooth traffic movement.
CO5: Identify appropriate traffic control and management measures.

Scope of Traffic Engineering and Study of its elements: Introduction, Objectives and Scope of Traffic Engineering; Components of Road Traffic – Vehicle, Driver and Road; Road User and Vehicle Characteristics and their effect on Road Traffic; Traffic Manoeuvres; Traffic Stream Characteristics- Relationship between Speed, Flow and Density

Traffic Engineering Studies and Analysis: Sampling in Traffic Studies, Adequacy of Sample Size; Objectives, Methods of Study, Equipment, Data Collection, Analysis and Interpretation (including Case Studies) of (a) Speed (b) Speed and Delay (c) Volume (d) Origin and Destination (e) Parking (f) Accident and other Studies.

Design of Traffic Engineering Facilities: Control of Traffic Movements through Time Sharing and Space Sharing Concepts; Design of Channelising Islands, T, Y, Skewed, Staggered, Roundabout, Mini-roundabout and other forms of AT-Grade Crossings including provision for safe crossing of Pedestrians and Cyclists; Grade Separated Intersections, their Warrants and Design Features; Bus Stop Location and Bus Bay Design, Design of Road Lighting.

Traffic Regulation and Management: Traffic Signs, Markings and Signals; Principles of Signal Design, Webster's and IRC method of Signal Design, Redesign of Existing Signals including Case Studies; Signal System and Coordination. Traffic Management measures - Speed, vehicle, parking, enforcement regulations, mixed traffic regulation, various management techniques.

References:

1. Federal Highway Administration, Manual on Uniform Traffic Control Devices (MUTCD), 2009.
2. Garber, N. J. and Hoel, L. A., Traffic and Highway Engineering, Cengage Learning, 2009
3. Hobbs, F. D., Traffic Planning and Engineering, Pergamon Press, 1979
4. IRC-SP41: Guidelines for the Design of At-Grade Intersections in Rural and Urban Areas
5. Kadiyali, L.R., Traffic Engineering and Transport Planning, Khanna publishers, 2011.
6. Matson, Smith and Hurd, Traffic Engineering, Mc-Graw Hill Book Co, 1955.
7. McShane W R and Roess R P, Traffic Engineering, Prentice-Hall, NJ, 2010
8. O'Flaherty C A, Highways- Traffic Planning and Engineering, Edward Arnold, UK, 2002
9. Pignataro, L., Traffic Engineering – Theory and Practice, John Wiley, 1973.
10. Salter, R J., Highway Traffic Analysis and Design, ELBS, 1996.
11. The Institute of Transportation Engineers, Traffic Engineering Handbook, 7th edn, 2016.

CE6202E TRANSPORTATION PLANNING

Pre-requisites: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Design and administer surveys to obtain the data required for transportation planning.
CO2: Estimate travel demand generation at aggregate and disaggregate levels
CO3: Determine travel demand distribution using growth factor methods and gravity models.
CO4: Develop mode split models, determine the shortest path and compute the travel demand
CO5: Develop land use integrated travel demand models.

Urban Transportation Planning Process and Concepts: Role of Transportation and Changing Concerns of Society in Transportation Planning; Transportation Problems and Problem Domain; Objectives and Constraints; Flow Chart for Transportation Planning Process- Inventory, Model Building, Forecasting and Evaluation Stages, Planning in System Engineering Framework; Concept of Travel Demand and its Modelling based on Consumer Behaviour of Travel Choices- Independent Variables, Travel Attributes.

Methods of Travel Demand Estimation: Assumptions in Demand Estimation- Sequential, Recursive and Simultaneous Process - Introduction to Transportation Planning Practices; Definition of Study Area, Zoning.
Trip Generation Analysis: Trip Generation Models- Zonal Models, Category analysis, Household Models, Trip Attractions of Work Centres and Commercial Trips
Trip Distribution Analysis: Trip End and Trip Interchange Models; Trip Distribution Models - Growth Factor Models, Gravity Models, Opportunity Models and their calibration; Estimation of Travel Demand based on link volume philosophy; Entropy based Trip Distribution models.

Mode Split and Route Split analysis: Mode Split Analysis- Mode Choice Behaviour, Competing Modes, Mode Split Curves, Probabilistic Models and Two Stage Mode Split Analysis; Route Split Analysis- Elements of Transportation Networks, Coding, Minimum Path Tress, Diversion Curves, All-or-Nothing Assignment, Capacity Restrained Assignment, Multipath Assignment.

Land use-Transportation Models: Location models - Opportunity Models, Lowry based Land use-Transportation Models – Allocation Function, Constraints, Travel Demand Estimation – Iterative Solutions, Matrix Formulation, Dynamic and Disaggregated extensions; Urban Forms and Urban Structures.

References:

1. Bruton M.J., Introduction to Transportation Planning, Hutchinson of London, 1970.
2. Cascetta, E., Transportation Systems Analysis, Springer, 2009
3. Dickey, J.W., Metropolitan Transportation Planning, Tata Mc-Graw Hill, 1980
4. Gallion A.B and Eisner S., The Urban Pattern, Affiliated East-West Press, New Delhi, 1993.
5. Hutchinson, B.G., Principles of Urban Transportation System Planning, Mc-Graw Hill 1974.
6. Kanafani, A., Transportation Demand Analysis, McGraw-Hill, 1983.
7. Khisty, C J., Transportation Engineering – An Introduction, Prentice-Hall, NJ, 2007
8. Meyer M.D. and Miller E.J., Urban Transportation Planning, McGraw-Hill International, 2001
9. Meyer, M. D, ITE Transportation Planning Handbook, John Wiley and Sons 2016
10. Oppenheim, N., Applied Models in Urban and Regional Analysis, Prentice-Hall, NJ, 1995.
11. Ortuzar J D and Willumsen L. G., Modelling Transport, John Wiley and Sons Ltd, 2001.

CE6203E PAVEMENT MATERIALS, DESIGN AND CONSTRUCTION

Pre-requisites: Nil

L	T	P	O	C
3	1	0	8	4

Total Lecture Sessions: 52

Course Outcomes:

CO1: Assess the pavement components with respect to their material composition.
CO2: Analyse pavement behaviour under varying traffic and environmental conditions.
CO3: Design the pavement with respect to field conditions.
CO4: Suggest suitable methodologies for the construction of durable and cost-effective pavements.

Pavement Materials: Types and Component parts of Pavements - A brief study on aggregates, bitumen and modified bitumen like cutback, emulsion, polymer modified bitumen - Bituminous mix design methods, specifications and testing – Superpave mix design and material testing - artificial aggregates – Industrial waste materials – Geo-polymer – waste plastics - fibres – recycled aggregate - nanomaterials.
Factors affecting Design and Performance of Pavements: Comparison between Highway and Airport pavements - Functions and Significance of Subgrade properties, Various Methods of Assessment of Subgrade Soil Strength for Pavement Design - Causes and Effects of variation in Moisture Content and Temperature - Depth of Frost Penetration.

Analysis and Design of Flexible Pavement: Stresses and Deflections in Homogeneous Masses - Burmister's 2- layer, 3- layer Theories - Wheel Load Stresses - ESWL of Multiple Wheels - ESAL – VDF - Repeated Loads and EWL factors - Sustained Loads and Pavement behaviour under Traffic Loads - Empirical, Semi-empirical, Analytical and Mechanistic-empirical approaches - Development, Principle, Design steps, Advantages and Applications of different Pavement Design Methods – Mechanistic-Empirical Pavement Design – IRC guidelines and examples.

Analysis and Design of Rigid pavements: Types of Stresses and Causes, Factors influencing the Stresses; General conditions in Rigid Pavement Analysis, ESWL, Wheel Load Stresses, Warping Stresses, Friction Stresses, Combined Stresses - Types of Joints in Cement Concrete Pavements and their Functions, Joint Spacing, Design of Slab Thickness, Design of Joint Details for Longitudinal Joints, Contraction Joints and Expansion Joints - Mechanistic Empirical Pavement Design - IRC guidelines and examples.

Pavement Construction: Earthwork – roadway excavation, embankment construction; Drainage -surface/subsurface, different types of drains; Subbase – Construction of gravel and stabilised bases; Base – WBM base, wet mix macadam; Bituminous pavements – interface treatments, binder course, surface and wearing course - Cement concrete pavements – base course, surface course - joints in plain and reinforced cement concrete pavements.
Sustainable Construction: Pavement Recycling - Full Depth Reclamation – porous pavements – warm mix technologies – Cold mix technologies.

References:

1. ASTM, AASHTO, SHRP and BIS publications.
2. Atkins, H. N., Highway Materials, Soils, and Concrete, Prentice Hall, 2002.
3. IRC: 37, Guidelines for the Design of Flexible Pavements.
4. IRC: 58, Guidelines for the Design of Rigid Pavements.
5. Kett I, Asphalt Materials and Mix Design Manual, Noyes Publications, 1999.
6. Kim Y. R., Modelling of asphalt Concrete, ASCE Press, 2008.
7. Lavin P G, Asphalt Pavements, Spon Press, 2003.
8. Mechanistic Empirical Pavement Design Guide, NCHRP, TRB, 2008.
9. MORTH Specifications for Road and Bridge Works.
10. Yang, Design of Functional Pavements, McGraw-Hill, 1973.
11. Yoder and Witezak, Principles of Pavement Design, John Wiley and sons, 1975.

CE6291E PAVEMENT ENGINEERING LABORATORY AND SEMINAR

Pre-requisites: Nil

L	T	P	O	C
0	0	2	1	1

Total Practical Sessions: 26

Course Outcomes:

CO1: Assess properties and suitability of materials for pavement construction.
CO2: Evaluate functional and structural conditions of pavements.
CO3: Prepare a document and presentation on selected topic.
CO4: Deliver a technical presentation on selected topic.

Properties of road aggregates: specific gravity – shape index – angularity number.

Properties of plain bitumen: specific gravity – penetration-softening softening point – viscosity – ductility.

Properties of modified bitumen: elastic recovery – storage stability – boiling test.

Properties of bitumen emulsion: viscosity – coagulation – coating ability – sieving on 600-micron sieve.

Rheological properties of bituminous binders: complex modulus – shear modulus – percent recovery.

Mix Properties: Marshall Stability and flow value – indirect tensile strength – tensile strength ratio – resilient modulus – rut resistance – fatigue life – stripping value.

Pavement properties: unevenness – roughness – rebound deflection – elastic modulus of pavement layer.

Seminar on any chosen relevant topic

References:

1. Atkins, H. N., Highway Materials, Soils, and Concrete, Prentice Hall, 2002.
2. Khanna, S.K., Justo, C.E.G. and Veeraragavan. A. Highway Materials and Pavement Testing, Nemchand and Bros, 2015.
3. Relevant AASHTO Guidelines.
4. Relevant ASTM Testing and Methodologies.
5. Relevant BIS Standards.

CE6292E COMPUTER APPLICATIONS IN TRANSPORTATION ENGINEERING LABORATORY

Pre-requisites: Nil

L	T	P	O	C
0	0	2	1	1

Total Practical Sessions: 26

Course Outcomes:

CO1: Design and draw at-grade and grade-separated intersections.
CO2: Design, draw longitudinal, and cross sections of road alignment
CO3: Design and draw on-street and off-street parking facilities
CO4: Model and forecast the travel demand

Design and Drawing Exercises

The following Detailed Drawings have to be prepared using CAD software:

i. Design and Drawing of At-Grade Intersections such as Square, T, Y and Rotaries.
ii. Design and Drawing of Grade Separated Intersections: Cloverleaf, Trumpet and Multilevel Intersections
iii. Design of Alignment of Roads given L/S and C/S and Drawing Optical Presentation of Details.
iv. Design and Drawing of Isolated Signals: Drawing to include Phasing, Split and Citing of Posts.
v. Design and Drawing of Signal Coordination System
vi. Sketching of Parking Garages, On-Street and Off-Street facilities

Hands-on Practice of Software

i. Design horizontal and vertical alignment of roads using Openroads / mXRoad / Civil 3D software
ii. Model and forecast travel demand using EMME, CUBE, TransCAD software

CE6211E THEORIES OF TRAFFIC FLOW

Pre-requisites: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Characterise traffic stream and model traffic flow using empirical and analogy approaches
CO2: Analyse the operation of interrupted flow using queuing theory and shockwave theory
CO3: Conduct the capacity and level of service for highway facilities
CO4: Develop simulation model of traffic flow and derive the relationships among traffic flow parameters.

Traffic Stream Characteristics and Description Using Distributions: Measurement, Microscopic and Macroscopic Study of Traffic Stream Characteristics - Flow, Speed and Concentration; Use of Counting, Interval and Translated Distributions for Describing Vehicle Arrivals, Headways, Speeds, Gaps and Lags; Fitting of Distributions, Goodness of Fit Tests.

Traffic Stream Models: Fundamental Equation of Traffic Flow, Speed-Flow-Concentration Relationships, Normalised Relationship, Fluid Flow Analogy Approach, Shock Wave Theory, Platoon Diffusion and Boltzman Like Behaviour of Traffic Flow, Car-Following Theory, Linear and Non-Linear Car-Following Models, Acceleration Noise **Queuing Analysis**: Fundamentals of Queuing Theory, Demand Service Characteristics, Deterministic Queuing Models, Stochastic Queuing Models, Multiple Service Channels, Models of Delay at Intersections and Pedestrian Crossings.

Highway Capacity and Level-of-Service Studies: Concepts, Factors Affecting Capacity and Level-Of Service, Capacity Analysis of Different Highway Facilities, Passenger Car Units, Problems in Mixed Traffic Flow.

Simulation Models: Philosophy of Simulation Modelling, Formulation of Simulation Model, Methodology of System Simulation, Simulation Languages, Generation of Random Numbers, Generation of Inputs – Vehicle Arrivals, Vehicle Characteristics, Road Geometrics, Design of Computer Simulation Experiments, Analysis of Simulation Data, Formulation of Simulation Problems in Traffic Engineering and Validation.

References:

1. Daamen, W., Buisson, C. and Hoogendoorn, S. P., Traffic Simulation and Data Validation - Methods and Applications, CRC Press, 2015.
2. Drew, D.R., Traffic Flow Theory and Control, McGraw-Hill, New York, 1968.
3. Gartner N.H, Rathi A.J. and Messer C.J., Traffic Flow Theory – A Revised Monograph, Transportation Research Board, Washington, 1997.
4. Mannering, F.L. and Kilareski, W.P., Principles of Highway Engineering and Traffic Analysis, John Wiley and Sons, 2008.
5. May, A D., Traffic Flow Fundamentals, Prentice-Hall, NJ, 1990.
6. McShane W R and Roess R P, Traffic Engineering, Prentice-Hall, NJ, 2010.
7. Neylor, T.H. et al., Computer Simulation Techniques, John Wiley, 1966.
8. TRB - SR No.165 - Traffic Flow Theory, Transportation Research Board, Washington, 1976.
9. TRB: Highway Capacity Manual, Transportation Research Board, Washington DC, 2000.

CE6212E TRANSPORTATION DATA ANALYSIS AND MODELLING

Pre-requisites: Nil

L	T	P	O	C
3	1	0	8	4

Total Lecture Sessions: 39

Course Outcomes:

CO1: Predict employment and population of an area
CO2: Analyse and forecast time series data using different approaches
CO3: Apply multivariate data analysis techniques to problems in Traffic and Transportation Planning
CO4: Develop models for analysis of transportation related choices.

Demographic and Employment Forecasting Models: Demographic Models - Linear, Exponential and Logistic Models; Cohort Survival Models - Birth, Aging and Migration Models; Employment Forecasting Models - Economic base Mechanism; Population and Employment Multiplier Models - Input and Output Models - Dynamic Models of Population and Employment – Multiregional Extensions.

Forecasting using Time Series Analysis: Basic Components of Time Series – Stationery and Non-Stationery Processes- Smoothing and Decomposition Methods – Correlation and Line Spectral Diagrams – Auto Correlations and Moving Averages. Box-Jenkins Forecasting Methodology: Examining correlations – Examining stationarity – Backshift notation – Autoregressive models – Moving average models – ARMA and ARIMA models – Model Identification – Parameter estimation. Traffic forecasting on highways: Basic Concepts and Methodology.

Multivariate Data Analysis Techniques: Types of Data, Basic Vectors and Matrices, Cluster Analysis, Exploratory and Confirmatory Factor Analysis, Multiple Discriminant Analysis, Logistic Regression, Overview of Structural Equation Modelling, MANOVA and Cross Classification Procedure in Multivariate Data Analysis and Application to Problems in Traffic and Transportation Planning.

Analysis and Modelling of Travel Choices: Revealed Preference and Stated Preference Survey Instruments, Formulation of a Stated Preference Survey Instrument, Random Utility Model, Probit, Logit and Discriminant Model Formulations, Nested Logit Model, Mixed Logit Model, Discrete - Continuous choice modelling methods – Model formulation and error assumptions, Estimation of MDCEV model, Application of Choice models, including MDCEV in forecasting.

References:

1. Ben-Akiva M., and Lerman, S. R., Discrete Choice Analysis - Theory and Application to Travel Demand, MIT Press, 1997.
2. Hair, J. F., Black, B., Babin, B., Anderson, R. E., and Tatham, R. L., Multivariate Data Analysis, Prentice Hall; 2005.
3. Hensher, D. A., Rose, J. M. and Greene, W. H., Applied Choice Analysis A Primer, Cambridge University Press, 2005.
4. Indian Roads Congress, Guidelines for Traffic Forecast on Highways, IRC 108-2015, 2015.
5. Koppelman, F. S. and Bhat, C., A Self Instructing Course in Mode Choice Modeling: Multinomial and Nested Logit Models, USDOT, 2006.
6. Makridakis S.G., Wheelwright S.C, and Hyndman R.J, Forecasting: Methods and Applications, Wiley, 1997.
7. Oppenheim, N., Applied Models in Urban and Regional Analysis, Prentice Hall, 1980.
8. Ortuzar, J. D., and Willumsen, L. G., Modelling Transport, John Wiley and Sons, 2011.
9. Washington, S. P., Karlaftis, M. G. and Mannering, F. L., Statistical and Econometric Methods for Transportation Data Analysis, Chapman and Hall/CRC, 2003.

CE6213E PAVEMENT EVALUATION AND MANAGEMENT

Pre-requisites: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Identify the causes of pavement surface distresses and suggest suitable remedial measures
CO2: Interpret the field condition and pavement design data with respect to present and future traffic
CO3: Optimize the maintenance alternatives based on the economic analysis of the project alternatives
CO4: Provide the feedback data for updating the pavement performance monitoring system.

Pavement Surface Condition and Its Evaluation: Various aspects of surface and their Importance – causes, factors affecting, deterioration and measures to reduce – pavement slipperiness, unevenness, ruts, potholes, and cracks – methods of measurement of skid resistance, unevenness, ruts and cracks – pavement surface condition evaluation by physical measurements - by riding comfort and other methods – their applications.

Pavement Structure and Its Evaluation: Factors affecting structural condition of flexible and rigid pavements – effects of subgrade soil – moisture – pavement layers – temperature – environment and traffic on structural stability – pavement deterioration – evaluation by non-destructive tests such as FWD, Benkelman Beam rebound deflection – plate load test – wave propagation and other methods of load tests – evaluation by destructive test methods and specimen testing.

Pavement Overlays and Design: Pavement overlays – design of flexible overlay over flexible pavement by Benkelman Beam deflection and other methods – bonded and unbonded overlays – flexible overlays and rigid overlays over rigid pavements – use of Geosynthetics in pavement overlays.

Pavement Management System: Concepts of pavement management systems – pavement performance prediction – concepts, modelling techniques – structural conditional deterioration models – mechanistic and empirical models – functional condition deterioration models – unevenness deterioration models and other models – ranking and optimization methodologies.

References:
1. Croney, D., The Design and Performance of Road Pavements, HMSO Publications, 2008.
2. Haas and Hudson, Pavement Management System, McGraw Hill Book Co., New York, 1982.
3. HRB/TRB/IRC/International Conference on Structural Design of Asphalt Pavements, 1988.
4. Huang, Y. H., Pavement Analysis and Design, Prentice Hall, 2003.
5. Shahin, M. Y., Pavement management for airport, roads and parking lots, Chapman and hall 2005.
6. Ullidtz, P., Pavement Analysis, Elsevier, Amsterdam,1998.
7. Woods, K.B., Highway Engineering Hand Book, McGraw Hill Book Co.
8. Yoder and Witezak, Principles of Pavement Design, John Wiley and sons, 1975.

CE6296E PROJECT: PHASE I

Pre-requisites: Nil

L	T	P	O	C
0	0	0	6	2

Course Outcomes:
CO1: Identify a potential topic for dissertation work
CO2: Prepare a document on the proposed work, based on literature survey and interactions
CO3: Prepare a presentation on the selected topic of study
CO4: Give an effective technical presentation on the selected topic.

The aim of the course 'Project: Phase I' is to introduce the students to various sub-fields in Transportation Engineering. The objective of the course is to expose the students to current developments and research activities in the related fields. The students are also trained to gather in-depth information on specified areas or topics. The students are made proficient to make proper technical documentation on the selected topic. Moreover, the course would also provide training to students to make effective technical presentations.

CE7297E PROJECT: PHASE II

Pre-requisites: Nil

L	T	P	O	C
0	0	0	9	3

Course Outcomes:
CO1: Identify, communicate and secure an internship from a professional organisation.
CO2: Understand work culture of the organisation, and develop attitudes, communication and interpersonal skills
CO3: Prepare a document and a presentation on the work done
CO4: Give an effective technical presentation on the work done.

The aim of this course is to enable the students to integrate the theoretical concepts in the courses credited during their first and second semesters of study with the practice in the field. The objective of the course is to enable the students to develop work culture, attitudes, as well as, communication and interpersonal skills necessary for job success. The students are made proficient to make proper technical documentation on the work done. Moreover, the course would train the students to make effective technical presentations.

CE7298E PROJECT: PHASE III

Pre-requisites: Nil

L	T	P	O	C
0	0	0	45	15

Course Outcomes:

CO1: Formulate the study methodology and design the questionnaire or data format
CO2: Develop database through primary surveys or experiments and secondary surveys
CO3: Conduct exploratory analysis of data and identify trends and patterns in the data
CO4: Prepare a document and a presentation, and give an effective technical presentation on the work carried out.

The primary objective of this phase of the 'Project' is to enable the students to develop a database, along with exploration of the same for the proposed study. It is envisaged that the students will be able to draw the methodology in line with the objectives set for the study based on the literature review done in the previous phase. The students will be trained to identify the study area, design the questionnaire/ data sheet and administer the survey or conduct investigations. The students will also be trained to gather data related to the topic of study by primary or secondary surveys and computerise the same for analysis. As part of this phase, the students are expected to develop templates in spreadsheet format for data cleaning and exploration. The students are also expected to identify the modelling framework, and the tools and techniques for development of models. The students are made proficient to make proper technical documentation on the selected topic. Moreover, the course would also provide further training to students to make effective technical presentations. Project Phase III and/or Phase IV can be carried out in industry as Internship. For students opting for internship, the course outcomes will depend on the actual work performed during the internship.

CE7299E PROJECT: PHASE IV

Pre-requisites: Nil

L	T	P	O	C
0	0	0	45	15

Course Outcomes:

CO1: Develop proficiency in using tools and techniques required for analysis and modelling
CO2: Develop models for estimation or forecasting
CO3: Conduct comparative analysis of alternative solutions or strategies and identify the best one
CO4: Prepare document and presentation, and give an effective technical presentation on the work carried out.

The primary objective of the course 'Project: Phase IV' is to expose the students to the tools and techniques for transportation modelling and forecasting. The students will be familiarised with the statistical techniques and software tools to characterise and model the traffic flow, travel demand or pavement materials and mixes. The students will get deep insights into the problem of study and be able to identify alternate solutions or strategies. These alternate scenarios, solutions or strategies will be evaluated with respect to relevant parameters for comparison and the best solution will be identified. The students are made proficient to make proper technical documentation on the study. Moreover, the course would also provide training to students to make effective technical presentations. Project Phase III and/or Phase IV can be carried out in industry as Internship. For students opting for internship, the course outcomes will depend on the actual work performed during the internship.

CE6221E TRANSPORTATION INFRASTRUCTURE DESIGN

Pre-requisites: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Design of geometric elements of highways based on performance analysis
CO2: Plan and develop facilities for non-motorised modes of transport and wayside amenities
CO2: Evaluate the warrants and design the at grade intersections and grade separated interchanges
CO3: Appraise the requirements in terminal facility planning.

Performance analysis of geometric design: Introduction - Guiding principles - Stakeholder considerations - Geometric design elements v/s performance categories - Geometric design performance measurements - Process Framework - Introduction to road design software.

Non-motorised transport and wayside amenities: Design of facilities: non-motorised transport and pedestrians: design considerations – wayside amenities - service area: site spacing, size and service facilities – bus-bays and truck lay-byes.

Design of Intersections: Types and Principles - At grade intersection: design elements, channelization - Rotary: Design and Capacity - Signalized intersection: warrants, design - Signal Co-ordination - Grade separated intersections: warrants, types, geometric standards - Ramp design: entry and exit, Gore area design.

Terminal Facilities: Principles - Process flow charts - Terminal analysis – Airport terminal: facility criteria – Airside, landside and terminal building facilities - Introduction to container terminals - planning area: seaside access and terminal quayside, terminal yards, hinterland access.

References:
1. Bose J. W., Handbook of Terminal Planning, Springer, 2020.
2. IRC 73: Geometric design standards for rural (non-urban) highways
3. IRC 86: Geometric design standards for urban roads and streets
4. IRC 92: Guidelines for the design of interchanges in urban areas
5. IRC 93: Guidelines for design and installation of road traffic signals
6. IRC: MORTH Guidelines for expressways, Volume II: Design
7. IRC-SP41: Guidelines for the design of at-grade intersections in rural and urban Areas
8. Kadiyali, L.R., Traffic Engineering and Transport Planning, Khanna publishers, 1987.
9. Morlock, E. K., Introduction to Transportation Engineering and Planning, International Student Edition, McGraw-Hill Book Company, New York, 1992.
10. NCHRP Report 659: Guide for the geometric design of driveways.
11. Transportation Research Board, Airport Passenger Terminal Planning and Design, Volume 1: Guidebook, 2010.

CE6222E TRANSPORTATION SYSTEMS MANAGEMENT

Pre-requisites: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Collect data and analyse the impacts of different TSM measures.
CO2: Analyse candidate TSM measures and propose a suitable TSM measure for a given situation
CO3: Identify appropriate travel demand management measures for a given area
CO4: Manage the parking demand in an area.
CO5: Plan and design for non-motorised transport and vulnerable road users.

Methodology and Data Collection: Methodological frame work, objectives and problems, conflicts resolution, strategic categories and action elements, travel behaviour impact and response time, TSM actions combinations and interactions, impact assessment and evaluation, monitoring and surveillance, Area wide data collection methodology, corridor data collection methodology.

TSM Actions: Study of following TSM actions with respect to problems addressed, conditions for applications, potential implementation problems, evaluation and impact analysis
Public transportation and HOV treatment, Toll discounts for car pools during peak periods, park and ride, carpooling, exclusive lanes, priority at ramp terminals, bus transfer stations, limited and skip-stop bus services, shared ride.

Demand Management: Staggered work Lecture Sessions, flexible work hours, high peak period tolls, shuttle services, circulation services, extended routes.
Traffic Operations Improvement: On-street parking ban, freeway ramp control and closure, travel on shoulders, one-way streets, reversible lanes, traffic calming, Right turn phase, right turn lanes, reroute turning traffic.

Parking Management: Short term reserved parking, increased parking rates, time duration limits, expanded off-street parking
Non-Motorized Transport: pedestrian only streets, Dial a ride for elderly and handicapped.

References:

1. Arlington D, Transportation System Management in 1980: State of the Art and Future Directions, Transportation Research Board, 1980.
2. Institute of Transportation Engineers, Transportation and Traffic Engg. Hand Book, Prentice Hall, 1982
3. TRB Publications.

CE6223E PUBLIC TRANSPORT PLANNING AND DESIGN

Pre-requisites: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Identify basic operating elements and travel characteristics of public transport
CO2: Identify principle, geometry and characteristics of transit lines and networks
CO3: Develop timetables for public transport systems
CO4: Develop schedules for the crew and vehicles for public transport systems

Basic Operating Elements: Line, network, stop and station-vehicles, transit units, and fleet size-, passenger flow and volume-operating elements-capacity, work, and utilization-travel time-speed;
Transit Travel Characteristics: Factors influencing transit travel, spatial distribution of transit travel, temporal variations of transit travel, passenger volume analysis and service capacity determination, characteristics of travel on a transit line, indicators of transit usage.

Transit Lines and Networks – Planning objectives, principles and Considerations-geometry of transit lines-types of transit lines and their characteristics: radial, diametrical, tangential, circumferential and loop lines, right of way in special alignments-transfers in transit networks: classification of transfers, metro station layouts and schedules for simultaneous transfers-timed transfer system networks-transit network types and their characteristics- analysis of metro network geometric forms.

Timetable Development – Objectives, Optional timetables and comparison measures. Anchoring the timetable to a single time point- Even headways with smooth transitions, Headways with average loads. Even maximum load on individual vehicles, minimum frequency standard, Optimization problem. Minimum passenger-crowding timetables for a fixed vehicle fleet. Timetable for maximum synchronization – Formulation an O-R model.

Vehicle Scheduling and Crew Scheduling: Estimation of fleet size required for a single route. Max-flow technique for fixed vehicle scheduling - Formulation and transformation of the max-flow problem. Deficit – function model with deadheading trip insertion. Fleet size lower bound for fixed schedules. Variable trip departure times – single route minimum fleet size, variable scheduling using deficit functions. Crew Scheduling: Vehicle chain construction using minimum crew – cost approach, arrival – departure joinings with hollows – Formulation of Objective function. Crew assignment procedures.

References:

1. Ceder, A, Public Transit Planning and Operation, Butterworth – Heinemann, 2007.
2. Chakraborty, P. and Das, A., Principles of Transportation Engineering, Prenctice Hall of India Pvt Ltd, 2003.
3. Grava, S., Urban Transportation Systems, Mc-Graw Hill, 2003.
4. Vuchic, V. R., Urban Transit: Operations, Planning and Economics, Wiley, 2005.
5. White, P., Public Transport, UCL Press, 2008.

CE6224E TRANSPORTATION AND LAND USE

Pre-requisites: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Identify the transportation technologies suitable for the urban area based on activity system and travel patterns in the given urban area.

CO2: Analyse the form and structure of an urban area.

CO3: Forecast population and employment in an area for horizon year.

CO4: Develop models of land use and transportation interactions.

CO5: Evaluate alternative land use transportation plans.

Travel Patterns, Transportation Technologies, Urban Forms and Urban Structure: Brief Study of Urban Travel Patterns and Urban Transportation Technologies; Land use-Transportation Planning Process - Hierarchy of Urban Activity System, Hierarchy of Urban Transportation Network and Technology; Relationship between Movement and Accessibility Functions of Transportation Network; Urban Structure and its Characteristics such as Centripetal, Grid Iron, Linear and Directional Grid types, Study of Urban Forms such as Garden City, Precincts, Neighbourhoods, Linear City, MARS Plan, LeCorbusier Concept, Radburn Concept, Environmental Area Concept.

Demographic and Employment Forecasting Models: Demographic Models - Linear, Exponential and Logistic Models; Cohort Survival Models - Birth, Aging and Migration Models; Employment Forecasting Models - Economic base Mechanism; Population and Employment Multiplier Models- Input and Output Models - Dynamic Models of Population and Employment – Multiregional Extensions

Land use-Transportation Models: Location models - Opportunity Models, Lowry based Land use-Transportation Models – Allocation Function, Constraints, Travel Demand Estimation – Iterative Solutions, Matrix Formulation, Dynamic and Disaggregated extensions.

Evaluation of Land use – Transportation Plans: Operational, Environmental and Economic Evaluation – Concept of Demand and Supply for Transportation Projects – Benefit and Cost – B/C and Cost Effective Approach for Economic Evaluation.

References:

1. Barra, T. D. L., Integrated Land Use and Transport Modelling, Cambridge University Press, 1995.
2. Cordera, R.,Ibeas, A., dell'Olio, L. and Alonso, B., Land Use–Transport Interaction Models, CRC Press, 2018.
3. Dickey J.W., Metropolitan Transportation Planning, Tata McGraw-Hill, 1988.
4. Gallion A.B and Eisner S., The Urban Pattern, Affiliated East-West Press, New Delhi, 2005.
5. Heggei, I.G., Transportation Engineering Economics, Mc-Graw Hill Book Company, New York, 1972.
6. Hutchinson B.G., Principle of Transportation Systems Planning, McGraw-Hill, 1974.
7. ITE, Transportation and Traffic Engineering Hand Book, Chapters 21 and 22, Prentice-Hall, New Jersey, 1982.
8. Oppenheim N., Applied Models in Urban and Regional Analysis, Prentice-Hall, 1980.
9. Wilson, A.G, Urban and Regional Models in Geography and Planning, John Wiley and Sons, 1974.

CE6225E TRANSPORTATION SYSTEMS AND ANALYSIS

Pre-requisites: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Identify the functions and problems associated with transportation planning.
CO2: Suggest a suitable transport system for a given requirement, by computing the power requirement and other parameters.
CO3: Identify the various factors influencing capacity and level of service for different transportation systems.
CO4: Identify and design the operational controls of different transportation systems

Transport Planning: Transportation and Society-Factors in Transportation Development: Functions and Problems in Transportation Planning-Economic, Geographical, Political, Technological, Social and Cultural Factors in Planning of Transportation System; A Brief Historical Development of Transportation Systems in India: Growth of Transport -Trends in Traffic - Imbalances in Transport System - New Evidences on Traffic Flow-Optimum Inter Model Mix-Study on National Transport Policy. (Students are expected to be introduced to the report on National Transport Policy).

Transport Technology: System Classification and their Variation; Study of Conventional Systems such as Automobile Taxi, Bus, Street Cars, Rapid Transit, Moving Belts, Tricycles and Bicycles and other Slow Moving Systems. Automatic Rapid Transit; Dual Modes, Demand Buses and Variation in other Slow Moving Vehicle Technologies; Unconventional Systems such as Automatic Cabin Systems, PRT Networks etc. Individual Vehicle Motion; Resistance of Air, Water and Ground Modes; Propulsion Forces, Basic Performance Relationships; Acceleration and Velocity Profiles.

Level of Service: Factors in Operation-Levels of Service and Performance Criteria - Quality of Service: Levels of Service of different Transportation Systems; Safety and Dependability-Flexibility-Speed, Acceleration, Deceleration-Comfort and Environmental Effects of the different Transportation System on the Performance Criteria.

Transportation Systems: Operational Controls of Air, Water, Railway and Highway Transportation Systems: Functions of Control and Communications-Despatching Policies - Interval Control - Signals and Traffic Control Devices - Navigational Aids of the different Transportation Systems. Air Traffic Control; Navigational Control. Automatic Signaling Systems of Railway and Highway Movements are proposed to be covered in this.

References:

1. Central Road Research Institute, Road user Cost Study in India, Final report, Central Road Research Institute, New Delhi, 1982,
2. Heggie, I.G., Transportation Engineering Economics, McGraw-Hill Book Company, New York, 1972.
3. ITE, Transportation and Traffic Engineering Handbook, Chapters 1,2,3,4,5,6,7 and 14, Prentice-Hall, N J., 1982.
4. Morlock, E. K., Introduction to Transportation Engineering and Planning, International Student Edition, McGraw-Hill Book Company, New York, 1978.
5. Planning Commission, Report of the National Transport Policy Committee, Govt. of India, 1980.
6. William, Hay, Introduction to Transportation Engineering, John Wiley, New York, 1978.

CE6226E GEOGRAPHIC INFORMATION SYSTEM AND ITS APPLICATIONS

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Identify the components of a GIS and the reference systems for mapping and data acquisition
CO2: Select suitable data representation tools and methods for analysis
CO3: Process the data to derive meaningful inferences for decision-making
CO4: Apply the tools and techniques available in GIS for the selected practical applications

Introduction: Definitions of GIS – Components of GIS – Geographic data presentation: maps – mapping process – coordinate systems – transformations – map projections – geo-referencing – data acquisition

Geographic Data Representation, Storage, Quality and Standards: Storage - Digital representation of data – Data structures and database management systems – Raster data representation – Vector data representation – Concepts and definitions of data quality – Components of data quality – Assessment of data quality – Managing data errors – Geographic data standards

GIS Data Processing, Analysis and Modelling: 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 – Surface modelling – DTM

GIS Applications: Applications of GIS in Environment monitoring – Natural hazard management – Natural resources management urban planning – utility management – Land information – Business development

References:

1. Burrough, P.A., Principles of Geographical Information Systems, Oxford Publication, 1998.
2. Chang, K-T., Introduction to Geographic Information Systems, McGraw Hill Education, 2016.
3. Clarke, K., Getting Started with Geographic Information Systems, Prentice Hall, New Jersey, 2010.
4. DeMers, M.N., Fundamentals of Geographic Information Systems, John Wiley and Sons, New York, 2002.
5. Heywood, I., Cornelius S. and Carver S., An Introduction to Geographical Information Systems, Pearson Education Ltd, Delhi, 2006.
6. Jeffrey, S. and John E., Geographical Information System – An Introduction, Prentice-Hall, 1990.
7. Jensen J R and Jensen R, Introductory Geographic Information Systems, Pearson Education Ltd, Delhi, 2013.
8. Lo, C.P. and Yeung A.K.W., Concepts and Techniques of Geographic Information Systems, Prentice Hall of India, New Delhi, 2006.
9. Reddy, A. M., Remote Sensing and Geographical Information Systems, B.S. Publications, Hyderabad, 2001.

CE6227E HIGHWAY SAFETY MANAGEMENT

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Identify the factors influencing the traffic safety
CO2: Measure the safety level and effects of various geometric elements on safety
CO3: Develop safety performance functions and predict safety on different category of roadways
CO4: Identify and design the appropriate safety measures for road traffic
CO5: Identify and design the suitable safety measures for pedestrians

Highway Geometrics: Highway Functions; Driver and Vehicle Characteristics; Cross Sections Design; Design Speeds; Horizontal Alignment; Vertical Alignment; Sight Distance; At-Grade intersections; Grade Separated Intersections; Signing; Marking and Islands; Traffic Calming.

Measurement of Road Safety: Human factors in road safety; Safety performance functions; Data needs and limitations; data analysis; road safety audit-applications, process, check lists, effectiveness; Accident Modification Factors; Safety Effects of Speed, Traffic volume and composition, Highway Design Elements, Traffic Control and Operational Elements, other Elements, Pedestrian and Bicycle Safety on Roadway Segments;
Safety Effects of Design Elements, Traffic Control, Operational Elements, and other Features; Pedestrian and Bicycle Safety at intersections; Safety Effects of Design, Traffic Control and Operations Elements at Interchange; Intersection manoeuvres; Star rating of roads

Predictive methods: Predictive methods for segments and intersections for Rural Two-Lane Roads, Rural Multilane Highways, urban and Suburban Arterials; Accident Modification Factors for Roadway Segments, Intersections, Interchanges, Special Facilities.

Road Safety Measures: Road Design and Road Equipment, Road Maintenance, Traffic Control, Vehicle Design and Protective Devices, Driver Training and Regulation of Professional Drivers, Public Education and Information, Police Enforcement and Sanctions;
Pedestrian safety Measures- Pedestrian Facility Design, Roadway Design, Intersection Design, Traffic Calming, Traffic Management, Signals and Signs, Other Measures.

References:

1. AASHTO, A policy on Geometric Design of Highways and Streets, AASHTO, 2004.
2. Babkov, V.F. Road Conditions and Traffic Safety. Mir Publishers, Moscow, 1975.
3. Elvik, R., Hoye, A., Vaa, T. and Sorensen, M., The Hand Book of Road Safety Measures, Emerald Group Publishing Limited, 2009.
4. Ezra Haure, Observational Before-After Studies In Road Safety, Pergamon, 2002.
5. IRC:73-1980-Geometric Design Standards for Rural (Non-Urban) Highways
6. IRC:86-1983- Geometric Design Standards for Urban Roads in Plains.
7. IRC:92-1985- Guidelines for Design of Interchanges in Urban Areas.
8. IRC-SP 41: Guidelines for the Design of At-Grade Intersections in Rural and Urban Areas.
9. ITE, Highway Safety Manual, ITE, 2010.
10. Ogden, K.W. Safer Roads: A Guide to Road Safety Engineering, Avebury Technical Cambridge
11. PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System, USDOT, 2004.

CE6228E HIGHWAY CAPACITY ANALYSIS

Pre-requisites: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Estimate the factors influencing capacity of a freeway segment and estimate the capacity of a freeway segment.

CO2: Estimate the capacity and level of service of a two lane and multilane highways.

CO3: Estimate the movement capacity of a sign controlled intersection considering the follow-up time and critical gap of vehicles.

CO4: Identify the factors influencing capacity and level of service of a roundabout and estimate the same using various models.

Highway capacity concepts: Concept of Capacity and Level of Service (LoS), Road user perceptions in LoS, Service Flow rates and volumes, v/c ratio and its use in Capacity analysis, Freeway capacity – Freeway capacity, Free flow speed, Flow characteristics, Speed flow density relationships, Factors affecting Free flow speed, Analysis methodologies for basic freeway sections, Calibration of passenger car equivalents, Driver population factor and Adjustment factors, Freeway weaving, Weaving configurations and their effects, Types of junctions, Ramps and Ramp Junctions – Capacity and LoS.

Two lane highways: Design standards, passing sight distance on two-lane highways, Capacity and Levels of Service, Determination of Free Flow speed, Determining of Demand Flow rate, Average travel speed, Percent time- spent – following, Determination of LoS.

Multilane highways: Weaving, merging and diverging movements on multilane highways, Characteristics and computational procedures of weaving segments, merge and diverge segments, Base conditions for multilane highways, Determination of Free flow speed, Determination of Capacity and LoS.

Sign controlled Intersections: Conflicting traffic in sign controlled intersections, Critical gap and follow-up time, Movement capacity, Impedance effects, Shared lane capacity, Two-stage gap acceptance, Estimation of queue lengths, Level of service criteria, Capacity and LoS estimation.

Roundabouts: Intersection control concepts, Capacity of roundabouts, Factors influencing capacity of roundabouts, Methods of estimating roundabout capacity, Models for estimation of roundabout capacity, LoS of roundabouts.

Signalised Intersections: Basic principles of intersection signalisation, discharge headways, saturation flow, LoS and Capacity, Left turn and right turn equivalencies, delay as a measure of effectiveness, Critical movement approach to signalised intersection analysis, Delay and LoS analysis.

Urban Street segments: Flow characteristics at urban streets, free flow speed, running speed, Time space trajectory, Level of Service, Data requirements for estimating LOS, Urban street classes.

Multimodal capacity analysis – Highway corridor facilities, Determination of segment capacity, Gate-tree-building capacity, Determination of segment free – flow and segment traverse times, Determination of queue delay, Performance measures, Transit and highway corridor analysis – Determination of bus stop capacity, Estimation of transit travel time and delay, Transit subsystem analysis.

References:

1. CSIR – Central Road Research Institute, Indian Highway Capacity Manual (Indo-HCM), 2017.
2. IRC: SP41, Guidelines for the Design of At-Grade Intersections in Rural and Urban Areas
3. IRC:64, Guidelines for Capacity of Roads in Rural Areas
4. IRC:73, Geometric Design Standards for Rural (Non-Urban) Highways
5. IRC:86, Geometric Design Standards for Urban Roads in Plains
6. IRC:92, Guidelines for the Design of Interchanges in Urban Areas
7. Roess, R.P., Prassas E.S. and McShane, W.R., ‘Traffic Engineering’, 4th Edition, Prentice Hall, 2010.
8. Transportation Research Board, National Academics, ‘Highway Capacity Manual (HCM), 2010.

CE6229E SIMULATION MODELLING OF TRANSPORTATION SYSTEMS

Pre-requisites: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Identify different types of systems and select appropriate simulation techniques.
CO2: Implement different techniques for random number generation and perform goodness-of-fit tests.
CO3: Verify and validate the simulation models.
CO4: Develop simulation models using software for different road facilities.

System Concepts - Systems and system environment, Components of a system, Discrete and continuous systems, Systems approach to problem solving, Types of system study, System analysis, system design and system postulation, System modelling, Types of models.
System Simulation - Technique of simulation, Comparison of simulation and analytical methods, Types of system simulation, Steps in simulation study, Monte Carlo simulation.
Concepts in Discrete Event Simulation - Event scheduling/Time advance algorithm, Modelling world views, Simulation programming tasks, Comparison and selection of simulation languages.

Random Number Generation: Techniques for generating random numbers, Linear congruential method, Test for random numbers, Frequency tests, run tests, tests for autocorrelation, gap test, and Poker test.
Random Variate Generation: Inverse transformation technique, Exponential, Uniform, Weibull, Triangular, Empirical-Discrete and continuous distributions. Convolution method, Acceptance-Rejection technique.
Input Modelling for Simulation: Data collection, Identifying the distribution with data, Parameter estimation, Goodness of fit test, Chi square test, Kolmogrov and Smirnov test, Anderson–Darling test, selecting input model when data are not available.

Verification and Validation of Simulation Models: Verification of simulation models, Calibration and validation of models, Face validity, Validation of model assumption, validating input-output transformation, Input-output validation using historical input data.
Output Analysis for a Single Model: Measures of performance and their estimation, Point estimation, Interval estimation, Output analysis for terminating simulations and Steady state simulations.

Simulation Modelling and Analysis of Transportation Systems: Objectives, Performance measures, Issues in simulation of transportation systems, Simulation software for transportation engineering applications, Simulation of midblock, intersections, pedestrian facilities, Cellular automata.

References:

1. Banks, J., Carson, J.S., Nelson, B.L., and Nicol, D.M., Discrete-Event System Simulation, Third Edition, Pearson Education, Inc., 2001.
2. Barceló, J., Fundamentals of Traffic Simulation, Springer, 2010.
3. Deo, N., System Simulation with Digital Computer, Prentice Hall of India, 1997.
4. John A. Sokolowski and Catherine M. Banks, Principles of Modeling and Simulation - A Multidisciplinary Approach, JOHN WILEY and SONS, 2009
5. Neylor, T.H. et al., Computer Simulation Techniques, John Wiley, 1966.
6. Robinson, S., Simulation: The Practice of Model Development and Use, John Wiley and Sons Ltd, 2004.
7. Singh V. P., System Modelling and Simulation, New Age International, 2009.

CE6230E TRAVEL DEMAND MODELLING

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Analyse classic travel demand modelling approach

CO2: Design survey instruments, administer travel surveys and conduct data exploration

CO3: Develop activity based travel demand models to understand activity-travel behaviour

CO4: Synthesise population and the urban travel demand

Introduction: Transport planning and modelling, Models and their role, Characteristics of transport problems, Characteristics of travel demand, Characteristics of transport supply, Equilibration of supply and demand, Issues in transport modelling, Classic travel demand model - trip generation, trip distribution, modal split, assignment, Limitations of trip based approach, Need for and introduction to activity based approach, comparative study of conventional and activity based approaches.

Data Needs and Methods: Data requirements, Travel surveys and their role in transport planning, Survey methods-manual, automatic and electronic methods, Precision and accuracy in travel surveys, Sample design, Sampling procedures, Design and administration of travel and activity surveys, Stated and revealed preference survey, Survey data – correction, expansion and validation, data exploration.

Activity based models: Theoretical background, Important features, Activities, Tours and trips, Linkage between trip, tour and activity performed, Individuals and representative individuals, Intra household interactions, Analysis of activity-travel behaviour, Characteristics by socio-economic market segment, Activity frequency analysis using linear regression models, Count data models of activity frequency, Discrete choice models of activity-travel demand, Applications and worked out problems.

Simulation modelling: Household synthesis, Personal synthesis, Activity travel synthesis, Monte Carlo and probabilistic processes, Study of activity based simulation models like DaySim, CEMDAP, FAMOS, CARLA, AMOS, ALBATROSS, TASHA. Applications of activity based models in travel demand forecasting

References:

1. Ben-Akiva, M. and Lerman, S., Discrete Choice Analysis: Theory and Application to Travel Demand, MIT Press, Cambridge, MA, 1985.
2. Dickey, J.W., Metropolitan Transportation Planning, Tata Mc-Graw Hill, 1980
3. Ettema, D. and H. Timmermans, eds., Activity-Based Approaches to Travel Analysis, Elsevier Science Ltd, 1997.
4. Goulias, K.G., ed., Transportation Systems Planning: Methods and Applications, CRC Press, 2003.
5. Hensher, D.A., ed., Travel Behaviour Research: The Leading Edge, Elsevier Science Ltd, 2001.
6. Hutchinson, B.G., Principles of Urban Transportation System Planning, Mc-Graw Hill, 1974.
7. Kanafani, A., Transportation Demand Analysis, McGraw-Hill, 1983.
8. Khisty, C J., Transportation Engineering – An Introduction, Prentice-Hall, NJ, 2007
9. Meyer, M.D. and E.J. Miller, Urban Transportation Planning, Second Edition, McGraw Hill, 2001.
10. Ortuzar, J de D. and L. Willumsen, Modelling Transport, Third Edition, John Wiley and Sons, 2001.
11. Papacostas, C.S. and P.D. Prevedouros, Transportation Engineering and Planning, Third Edition, Prentice Hall, 2001.
12. Timmermans, H., ed., Progress in Activity-Based Analysis, Elsevier Science Ltd, 2005.
13. Washington, S.P., M.G. Karlaftis, and F.L. Mannering, Statistical and Econometric Methods for Transportation Data Analysis, Chapman and Hall/CRC, 2003.

CE6231E ROAD ASSET MANAGEMENT

Pre-requisites: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Develop pavement management system based on the data requirements
CO2: Establish the selection criteria for choosing maintenance and rehabilitation strategies
CO3: Optimise the maintenance alternatives based on the economic analysis of project alternatives
CO4: Provide the feedback data for updating the pavement performance monitoring system

Pavement Management Process and Data Requirements: Pavement Management System (PMS) Evolution of pavement management – requirements for an effective and comprehensive PM – application of system concepts to pavement management – pavement management levels and functions – Data needs – pavement inventory – assessment of pavement performance – evaluation of pavement structural capacity – distress and safety – combined measures of pavement quality – data management.

Determining Present and Future Needs: Establishing criteria – development of prediction models for pavement deterioration – MEPDG approach – determining the future needs – rehabilitation and maintenance strategies – deterioration modelling of maintenance and rehabilitation alternatives – priority programming of maintenance and rehabilitation – developing combined programmes for maintenance and rehabilitation.

Project Level Design: Framework for pavement design – characterization of design inputs – MEPDG – basic structural response models – variability, reliability and risk – generation of alternate design strategies – pavement analysis and design of bituminous and concrete pavements - rehabilitation design procedures – economic evaluation of alternate pavement maintenance and rehabilitation strategies – selection of optimal design strategy.

Implementation: Major steps and key components in implementing PMS – role of pavement construction and maintenance in pavement management – information, research needs – cost and benefit of pavement management – future directions and need for innovations in pavement management.

References:

1. Brown, S., Pavement Management Systems, Transportation Research Board, 1993.
2. Haas R., Ronald H. W., and Falls, L. C., Pavement Asset Management, John Wiley and Sons Inc., Scrivener Publishing, 2015.
3. Haas R., Hudson, R. W., and Zaniewski, J. P., Modern Pavement Management, Krieger Publishing Company, 1994.
4. OECD, Pavement Management Systems, O E C D, 1987.
5. Shahin, M Y, Pavement management for airport, roads and parking lots, Chapman and hall, 1994

CE6232E TRANSPORTATION ECONOMICS AND APPRAISAL

Pre-requisites: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Apply the economic principles and estimating the various cost components in transportation
CO2: Formulate possible project alternatives for the economic analysis and apply the appropriate economic analysis method
CO3: Apply various non-economic based economic analysis techniques for transportation projects
CO4: Quantify the energy, environment and safety consequences of transportation in the economic analysis

Transport Costs and Benefits: Principles of economic analysis, Fixed and variable cost, cost of improvement, maintenance cost, cost estimating methods, accounting for inflation, external costs; Consequences of transport projects, road user consequences - reduced vehicle operation costs, value of travel time savings, value of increased comfort and convenience, cost of accident reduction, reduction in maintenance cost, non-user consequences – travel time.

Economic Analysis Methods: Generation and screening of project alternatives, different methods of economic analysis: annual cost and benefit ratio methods, discounted cash flow methods, shadow pricing techniques, determination of IRR and NPV, examples of economic analysis, application economic theory in traffic assignment problem.

Non-Economic based Project Appraisal: Multi-criteria analysis – Simple non-compensatory methods, Simple additive model – sensitive testing, probabilistic additive weighing, checklists, case study, Analytic Hierarchy Process – Hierarchies, Establishing priorities within hierarchies, establishing and calculating priorities, Relationship AHP and Simple additive weighing.

Environmental and Safety Evaluation: Introduction, air pollutants, pollutant effects, air quality standards, factors influencing air pollution, air pollution dispersion and pollution models, air pollution reduction measures - Noise pollution: noise measurement, noise propagation, noise modelling, noise control and abatement techniques, Energy related issues, energy consumption of different modes, energy related transportation actions; Highway safety problem, accident categories, highway safety improvement program – planning, implementation and evaluation stages, steps in HSIP, counter measures for accidents and probable causes, road safety audit.

References:

1. Button, K. J., Transport Economics, Elgar, 2010.
2. Canter, L.W., Environmental impact assessment, McGraw-Hill, 1997
3. Central Road Research Institute, Road User Cost Study, 1982.
4. Dickey J.W, Project Appraisal for Developing Countries, John Wiley, 1984
5. Heggie, I. G., Transportation Engineering Economics, McGraw-Hill, 1972.
6. Hensher, D. A., and Brewer, A. M., Transport: An Economics and Management Perspective, Oxford University Press, 2001.
7. Marriott B. B., Environmental Impact Assessment: A Practical Guide, McGraw-Hill Professional, 1997.
8. Quinet, E., and Vickerman, R., Principles of Transport Economics, Edward Elgar Pub, 2005
9. Rogers, M., Engineering Project Appraisal, Blackwell Publishing, 2012.
10. Winfrey R, Highway Economic Analysis, International Textbook Company, 1969.

CE6233E ENVIRONMENTAL IMPACT ASSESSMENT OF TRANSPORTATION PROJECTS

Pre-requisites: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Understand the concepts, prevailing policy frameworks and acts with regard to environmental protection
CO2: Develop suitable methodological framework for conduction EIA studies
CO3: Predict and assess the impact on Air, Noise and Social environment
CO4: Select the alternatives through systematic decision-making methodologies
CO5: Conduct and record public participation in the EIA process

Introduction: Concepts of environmental impact analysis, key features of National environmental policy act and its implementation, screening in the EIA process, utility and scope of EIA process, Environmental protection acts EIA at national level.
Conceptual approach for environmental impact studies, planning and management of impact studies, matrix and network methodologies for impact identification, description of the affected environmental – environmental indices.

Prediction and Assessment of Impact on Air Environment: Basic information on air quality, sources of air pollutants, effects of air pollutants, key legislations and regulations, conceptual approach for addressing air environment impacts, impact prediction approaches, assessment of significance of impacts, identification and incorporation of mitigation measures.

Prediction and Assessment of Impact on Noise and Social Environment: Basic information on noise, key legislation and guidelines, conceptual approach for addressing noise environment impacts, impact prediction methods, assessment of significance of impacts, identification and incorporation of mitigation measures Conceptual approach for addressing socio-economic impacts, traffic and transportation system impacts, visual impacts, scoring methodologies for visual impact analysis.

Decision Methods for Evaluation of Alternatives: Conceptual basis for trade-off analysis, weighting of decision factors, scaling, rating or ranking of alternatives, development of decision matrix.
Public participation in environmental decision making: Regulatory requirements, advantages and disadvantages, environmental impact assessment process, objectives of public participation, selection of public participation techniques, techniques for conflict management and dispute resolution, verbal communication in EIA studies.

References:
1. Canter, L.W., Environmental impact assessment, McGraw-Hill, 1997
2. Jain, R. K., Urban, L. V., Stacey G. S., and Balbach, H. E., Environmental Assessment, McGraw-Hill Professional, 2001.
3. Marriott, B. B., Environmental Impact Assessment: A Practical Guide, McGraw-Hill Professional, 1997.
4. Morris, P. and Therivel, R., Methods of Environmental Impact Assessment, Routledge, 2001.
5. Tolliver, D., Highway Impact Assessment, Greenwood Publishing Group, 1993.

CE6234E HIGHWAY SAFETY ANALYSIS AND MODELLING

Pre-requisites: Nil

L	T	P	O	C
3	0	0	6	3

Course Outcomes:

CO1: Identify the variables contributing to road crashes
CO2: Collect road crash data and formulate modelling
CO3: Perform statistical analysis of crash data
CO4: Identify safety solutions to reduce crashes

Highway Safety: Introduction to Highway Safety; Characteristics of Road User, Motor Vehicle, Roadway - Relationship between Elements - Human Factors governing Road User Behaviour; Reactive Approach - Risk factors for Traffic Crashes - Exposure to Risk - Crash Involvement - Crash Severity - Crash process from the Perspectives of Drivers, Roadways and Vehicles; Crash Data Collection Sources and Procedure; Proactive Approach – Overview of Surrogate Safety Measures - Pragmatic and Theoretical Approach.

Highway Safety Analysis: Identification of Hazardous Locations and Elements - Frequency Rate Method - Frequency Matrix - Spot Map - Accident Severity Method - Accident Rate Method - Hazard Index Method; Exploratory Analyses of Safety Data - Quantitative and Graphical Techniques; Cross-sectional and Panel Studies; Before and After Scenario Analysis – Survival Analysis - Naive Adjustment Method; Propensity Score Method; Geospatial Hotspot Methods; Screening Evaluation.

Highway Safety Modelling: Regression Methods - Poisson Distribution - Chi-squared Test for Comparing Crash Data - Quality Control Method; Crash Data Modelling – Crash Severity Modelling - Frequency Modelling; Spatial Data Modelling - Spatial Indicators - Getis G and Moran's I - Spatial Regression Methods; Capacity, Mobility and Safety; Modelling for Injury Severity Modelling; Non Parametric Modelling Techniques; Bayesian Theory, Real-Time Crash Prediction Models.

Applications of ML in Highway Safety: Data Mining and Machine Learning Techniques in Highway Safety - Association Rules - Clustering Analysis - Decision Tree Models - Bayesian Networks - Neural Networks - Support Vector Machines - Negative Binomial Regression Models and Estimation Methods; Safety Solutions.

References:

1. AASHTO, 2010. Highway safety manual, 1st Edition. In: American Association of State Highways and Transportation Officials, Washington, D.C.
2. Cameron, A.C., and Tridevi, P.K., Regression Analysis of Count Data, second ed, Cambridge University Press, 2013
3. Ezra H., Observational Before-After Studies in Road Safety, Pergamon, 2002
4. Ezra H., The Art of Regression Modeling in Road Safety, Springer, 2015
5. Hilbe, J.M., Modelling Count Data, Cambridge University Press, 2014.
6. Lord D., Qin X., and Geedipally S. R., 2021. Highway Safety Analytics and Modelling, Elsevier.
7. Lord, D., Washington, S., 2018. Safe Mobility: Challenges, Methodology and Solutions (Transport and Sustainability, Vol. 11. Emerald Publishing Limited.
8. McCulloch, C.E., Searle, S.R., and Neuhaus, J.M., Generalized, Linear, and Mixed Models, Second ed. John Wiley and Sons Inc., 2008
9. WHO, Global Status Report on Road Safety, World Health Organization, WHO Press, Geneva, Switzerland.

CE6235E STATISTICAL ANALYSIS OF TRANSPORTATION DATA

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Formulate the different probability distributions and their corresponding distribution functions.

CO2: Estimate the parameters of models and formulate the test hypothesis for mean and variance.

CO3: Design the experiments using different methods.

CO4: Develop models using regression analysis

Basic Probability Concepts: Sample space and events, Measures of probability, Probability Axioms, Conditional probability, Total probability, and Bayes' theorem.
Random variables and their properties: Probability Mass function, Probability density function, Descriptors of random variables, multiple random variables, associated random variables and probabilities. Probability Distributions**:** Discrete and continuous probability distributions.

Parameter Estimation and Hypothesis Testing: Properties of Estimators, Estimation of confidence intervals, Point estimators, the method of maximum likelihood, and the method of moments. Confidence interval estimation of – mean, and variance. Statistical hypothesis tests, Operations characteristic curve. Tests of hypothesis on the mean of a Normal Distribution, Tests of hypothesis on the means of two Normal distributions, Paired t-test, Tests of hypothesis on one variance, Tests of hypothesis for the equality of two variances, testing of goodness of fit. Analysis of categorical data – Chi-square goodness-of-fit, Non-parametric tests – Mann-Whitney W test, Wilcoxon rank signed-rank test.

Design of Experiments: Fundamental assumptions of analysis of variance, single factor experiments, Randomised complete block designs, Design of experiments with several factors- Two-factor factorial experiments, Latin square designs, Random effects, and mixed effect, 2^K factorial designs. Design of RP and SP survey instruments.

Correlation and Regression Analysis: Introduction, Linear and Non-linear correlation analysis, Assumptions, Estimation of simple regression models, Non-linear regression models, multiple linear regression models, Goodness-of-fit measures, Count data models.

References:

1. Benjamin, J., R. and Cornell, C. A., Probability, Statistics and Decision for Civil Engineers, Dover Publications Inc., 2014.
2. Cheremisinoff, N.P., Practical Statistics for Engineers and Scientists, CRC Press, 2019.
3. Gupta, B.C., Guttman, I., and Jayalath, K.P., Statistics and Probability with Applications for Engineers and Scientists using Minitab, R and JMP, Wiley and Sons, 2020.
4. Johnston, J. and Dinardo, J.; "Econometric Methods", 4th edition, McGraw-Hill International Editions, (1997)
5. Scott, D. W., Statistics: A Concise Mathematical Introduction for Students, Scientists and Engineers, John Wiley and Sons, 2021.
6. Soong T. T., Fundamentals of Probability and Statistics for Engineers, John Wiley and Sons, 2014.

CE6236E MACHINE LEARNING APPLICATIONS IN TRANSPORTATION ENGINEERING

Pre-requisites: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Identify the processes, classification and algorithms of Machine Learning

CO2: Execute different types of Deep Learning algorithms

CO3: Apply Reinforcement Learning techniques

CO4: Demonstrate the application of Machine Learning in Transportation Engineering problems

Introduction to Machine Learning: The Machine Learning (ML) process- classical Machine Learning Algorithms-I-Classical Machine Learning Algorithms-II- Bayesian Classifier-parametric and non-parametric estimation techniques-Unsupervised Learning and Clustering-dimensionality reduction techniques-search algorithms in AI.

Deep Learning: Deep Learning basics: Artificial Neural Networks, backpropagation and further optimizations, Convolutional Neural Network (CNN), Sequence Modelling: RNN, LSTM, GRU, Generative Adversarial Network (GAN).

Reinforcement learning: Introduction, motivation and brief history, Markov Decision process, Reinforcement Learning: Monte Carlo and Temporal Difference Methods, Reinforcement Learning: policy gradient methods, Partially Observable Markov Decision Process (POMDP).

Applications in Transportation Engineering: Use of Infrastructure-based data and sensing - Vehicle on-board data and sensing and Aerial sensing for ground transportation data; Case studies on the following: Use of NN in traffic signal control, car following control and bus bunching control. Use of transfer learning in vehicle detection enhancement, parking information management and prediction system, night time traffic detection and simulation to real-world knowledge transfer for driving behaviour recognition; Use of ML in traffic prediction and vehicle trajectory prediction.

References:

1. Abualigah L., Classification Applications with Deep Learning and Machine Learning Technologies. Springer Nature; 2022
2. Auffarth B., Machine Learning for Time-Series with Python: Forecast, predict, and detect anomalies with state-of-the-art machine learning methods. Packt Publishing Ltd; 2021.
3. Das L. B., George S. N., and Aprem A., Artificial Intelligence and Machine Learning: Theory and Practice, I.K. International Pvt. Ltd., New Delhi, 2023.
4. Jiang H. Machine learning fundamentals: A concise introduction. Cambridge University Press; 2021.
5. Witten I.H, Frank E. Data Mining Practical Machine Learning Tools and Techniques. Elsevier 2002.
6. Yan R, Wang S. Applications of Machine Learning and Data Analytics Models in Maritime Transportation. IET; 2022.

CE6237E FREIGHT TRANSPORT MODELLING

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Classify commodities and .compare various freight transport systems
CO2: Collect freight data and formulate aggregate/disaggregate freight demand models
CO3: Estimate freight generation, distribution, mode split and route split
CO4: Develop disaggregate and tour based freight mode choice models

Freight and Freight Transport Systems: Commodities and their classification systems; Technological and Operational characteristics of various freight transport systems like Air, Road, Rail, Water, Pipeline, Container and their merits and demerits

Freight Demand Estimation: Freight demand, Factors controlling freight demand, Freight traffic flow, Freight data collection, Growth factor methods for freight forecasting
Economic Activity Models: Modelling framework, Spatial Input-Output Model, Data requirements, Socio-economic data, Economic activity data, Land Use data and transportation network data.

Four-step freight forecasting: Trip generation, Trip distribution, Mode split, Network assignment – Influencing factors, Model formulation, Estimation of parameters, Model validation, Conversion to vehicle flows.

Freight mode choice: Models, Factors, Data collection; Basic concepts of discrete choice modelling, Estimation and application of MNL models, Nested logit models, GEV Models, Mixture logit models, Elasticities.

References:

1. Beagan, D., Fischer, M., and Kuppam, A. Quick Response Freight Manual II, Federal Highway Administration, U.S. Department of Transportation, 2007.
2. Ben-Akiva, M., and Meersman, H., Freight Transport Modelling, Emerald, 2013.
3. Ben-Akiva, M., Bierlaire, M., Bolduc, D., and Walker, J., Discrete Choice Analysis, 2010.
4. Center for Urban Transportation Research, Analysis of Freight Movement Mode Choice Factors, University of South Florida, 2006
5. Chari, S. R., Chandrasekhar B. P., and Subrahmanya, S. V., Highway Freight Characteristics of Hyderabad Region, Paper No. 382, Indian Roads Congress, 1987.
6. Cullinane K., and Neal, T., Identifying Influential Attributes in Freight Route/Mode Choice Decisions: A Content Analysis. Transportation Research Part E 36: 41-53, 2000.
7. Fei, J., Paul. H., and Calzada, C., Freight Demand Characteristics and Mode Choice: An Analysis of the Results of Modeling with Disaggregate Revealed Preference Data, Journal of Transportation and Statistics, 149-158, 1999.
8. Konstadinos, G. G., Transportation System Planning: Methods and applications, CRC Press, 2003.
9. Ortúzar, J. D., and Willumsen, L. G., Modelling transport, Wiley Publication, 2011.
10. U.S. Department of Transportation, Travel Survey Manual, 1996.
11. Windisch E., A Disaggregate Freight Transport Model of Transport Chain and Shipment Size Choice, Association for European Transport and Contributors, 2010.

CE6238E OPTIMISATION OF TRANSPORTATION SYSTEMS

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Formulate and solve linear programming problems.

CO2: Perform sensitivity analysis and solve transportation and assignment problems.

CO3: Formulate and solve integer linear programming and game theoretical problems.

CO4: Formulate and solve network path models.

Elementary Linear Programming: Systems of linear equations and inequalities – Convex sets – Convex functions – Formulation of linear programming problems - Theory of Simplex method – Simplex Algorithm – Charne's M-Method – Two phase method – Duality in linear programming – Dual Simplex method.

Advanced Linear Programming: Sensitivity analysis – Parametric programming – Bounded Variables problem – Transportation problem – Integrality property – MODI method – Degeneracy – Unbalanced problem – Assignment Problem – Development of Hungarian method – Routing problem.

Integer linear programming – Gomory's cutting plane method – Branch and Bound Algorithm – Travelling Salesman problem – Knapsack problem; Introduction to Optimization tools and software.
Rectangular Games – Two person – zero sum games – Pure and mixed strategies – 2-x n and mx 2 games. Relation between theory of games and linear programming.

Network Path Models: Tree Networks – Minimal Spanning Tree –Kruskal's Algorithm ,Prim's Algorithm- Shortest path problems – Solution methods – Dijkstra's Method – Floyd's Algorithm – Network flow Algorithms – Maximal flow algorithm – The method of Ford and Fulkerson

References:

1. Bazarra M. S. Jarvis J. J, and Sherali, H. D., Linear programming and Network flows – John Wiley, II edition, 1990.
2. Hillier, F. S. and Lieberman, G. J., Introduction to Operations Research, McGraw Hill Education, 2015.
3. Kwon, R. H., Introduction to Linear Optimization and Extensions with MATLAB, CRC Press, 2014.
4. Matoušek J. and Gärtner B., Understanding and Using Linear Programming, Springer, 2007.
5. Taha. H. A., Operations Research, An Introduction Prentice Hall India, 2006.
6. Thie, P.R. and Keough, P.E., An Introduction to Linear Programming and Game Theory, John Wiley and Sons, 2008.
7. Vella, D. C., Invitation to Linear Programming and Game Theory, Cambridge University Press, 2021.

CE6239E LOW VOLUME ROADS

Pre-requisite: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Suggest appropriate horizontal and vertical alignments of rural roads

CO2: Analyse and select suitable quality materials to the road construction

CO3: Design flexible, semi-rigid and rigid pavement based on field conditions

CO4: Implement suitable construction methods and assess the quality control and monitoring

Planning and Alignment of Low Volume Roads: Planning – Alignment and surveys – governing factors for route selection – factors controlling alignment – special considerations for hill roads.
Geometric Design of Low Volume Roads: Classification of roads – design speed – principles of geometric design – cross-sectional elements – roadway width at cross drainage structures – camber – sight distances – horizontal alignment – vertical alignment – alignment compatibility – hair-pin bends – passing places – lateral and vertical clearances – traffic requirements.

Road Materials: Purpose, components and load carrying mechanisms – soil properties – marginal materials – embankment and subgrade materials – stabilised soils – road aggregates – new materials and stabilisers – materials for bituminous construction - Marshall method of mix design – bituminous surfacing – semi-rigid pavement – rigid pavement – special pavements – roller compacted concrete - cell filled concrete – prefabricated concrete panels.

Pavement Design: Factors affecting pavement design **–** traffic, subgrade strength, layer properties, climatic conditions – failure criteria and reliability – design of pavement –flexible, semi-rigid and special pavements – IRC guidelines and worked-out examples.
Road Drainage: Types of drainage – general criteria for road drainage – system of drainage – surface and subsurface drainage – Cross drainage structures.

Road Construction and Quality Monitoring: Selection of materials and methodology – embankment and subgrade – granular subbase and base courses – shoulder – bituminous construction – semi-rigid pavement construction – concrete pavement – special pavements – quality monitoring and control during road construction – specifications and code of practice – field testing.

References:

1. Douglas, R. A., Low Volume Road Engineering: Design, Construction and Maintenance, CRC Press, Taylor and Francis, 2016.
2. IRC SP 20: Rural Roads Manual
3. IRC SP 40: Hill Road Manual
4. IRC SP 62: Guidelines for the Design and Construction of Cement Concrete Pavement for Rural Roads
5. IRC SP 72: Guidelines for the Design of. Flexible Pavements for Low Volume Roads
6. MORD Quality Assurance Hand Book for Rural Roads (Vol. I and II), Indian Roads Congress.
7. MORD Specifications for Rural Roads, Indian Roads Congress.

CE6240E ALTERNATIVE MATERIALS AND METHODS FOR ROAD CONSTRUCTION

Pre-requisites: Nil

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Evaluate the challenges of conventional road construction
CO2: Suggest alternative materials for road construction
CO3: Design methods for alternative and innovative bituminous mixes
CO4: Suggest suitable processes to implement pavement recycling.

Challenges in Conventional Road Construction: Flexible pavement: layers, requirements, construction – Rigid pavements: layers, requirements, construction – Excavation, Filling of embankment and drainage – quality control.

Alternative Materials for Road Construction: Necessity – Bitumen: production, replacement, uses – Aggregate: Production, replacement, uses – challenges in Subgrade preparation: Ground Improvement - Industrial wastes as construction materials – Natural fibres and textiles - Nanomaterials.

Design of Alternative Mixes: Hot mix asphalt: challenges – warm mix technology: design guidelines, modifiers, challenges – cold mix design: design guidelines, additives, challenges - Porous asphalt: design, advantages, challenges **–** Stone matrix asphalt (SMA): design, advantages, and challenges.

Pavement Recycling: Necessity – Recycling: Hot in place recycling (HIR), Cold in place recycling (CIR), Hot in plant recycling (HIP), Cold in-plant recycling (CIP), Reclaimed asphalt pavement (RAP) - Full depth reclamation (FDR): Advantages and challenges.

References:
1. IRC 120, Recommended Practice for Recycling of Bituminous Pavements
2. IRC SP: 101, Guidelines for Warm Mix Asphalt
3. IRC SP: 79, Tentative Specification for Stone Matrix Asphalt
4. IRC, Guidelines for Design and Construction of Low Volume Rural Roads using Coir Geotextiles.
5. IRC: SP:100, Use of Cold Mix Technology in Construction and Maintenance of Roads using Bitumen Emulsion.
6. Kandhal P. S., Veeraragavan A., and Choudhury R., Bituminous Road Construction in India, PHI Learning, 2023.
7. Kumar, R. S., Pavement Design, Universities Press Pvt Ltd., 2016.
8. Sherwood, P. T., Alternative Materials in Road Construction, Thomas Telford Ltd, 1995.
9. Specifications for Roads and Bridges, MoRTH, 5th Revision, 2013.

IE6001E ENTREPRENEURSHIP DEVELOPMENT

Pre-requisites: Nil

L	T	P	O	C
2	0	0	4	2

Total Lecture Sessions: 26

Course Outcomes:

CO1: Describe the various strategies and techniques used in business planning and scaling ventures.
CO2: Apply critical thinking and analytical skills to assess the feasibility and viability of business ideas.
CO3: Evaluate and select appropriate business models, financial strategies, marketing approaches, and operational plans for start-up ventures.
CO4: Assess the performance and effectiveness of entrepreneurial strategies and actions through the use of relevant metrics and indicators.

Entrepreneurial Mindset and Opportunity Identification
Introduction to Entrepreneurship Development - Evolution of entrepreneurship, Entrepreneurial mindset, Economic development, Opportunity Recognition and Evaluation - Market gaps - Market potential, Feasibility analysis - Innovation and Creativity in Entrepreneurship - Innovation and entrepreneurship, Creativity techniques, Intellectual property management. .

Business Planning and Execution
Business Model Development and Validation - Effective business models, Value proposition testing, Lean startup methodologies - Financial Management and Funding Strategies - Marketing and Sales Strategies - Market analysis, Marketing strategies, Sales techniques - Operations and Resource Management - Operational planning and management, Supply chain and logistics, Stream wise Case studies.

Growth and Scaling Strategies
Growth Strategies and Expansion - Sustainable growth strategies, Market expansion, Franchising and partnerships - Managing Entrepreneurial Risks and Challenges - Risk identification and mitigation, Crisis management, Ethical considerations - Leadership and Team Development - Stream wise Case studies.

References:

1. Barringer, B. R., Entrepreneurship: Successfully launching new ventures. Pearson Education India, 2015.
2. Biswas, D., and Dey, C., Entrepreneurship Development in India, Taylor and Francis, 2021.
3. Gordon E., and Natarajan K., Entrepreneurship Development, 6th Ed, Himalya Publishers, Delhi 2017.
4. Kaplan, J. M., Warren, A. C., and Murthy V., Patterns of entrepreneurship management. John Wiley & Sons, 2022.
5. Kuratko, D. F. *Entrepreneurship:* Theory, process, and practice. Cengage learning, 2016.
6. Shah, R., Gao, Z. and Mittal, H. Innovation, Entrepreneurship, and the Economy in the US, China, and India, Academic Press, 2014.
7. Sundar, K., Entrepreneurship Development, 2nd Ed, Vijaya Nichkol Imprints, Chennai, 2022.

MS6174E TECHNICAL COMMUNICATION AND WRITING

Pre-requisites: Nil

L	T	P	O	C
2	1	0	4	2

Total Lecture Sessions: 26

Course Outcomes:

CO1: Apply effective communication strategies for different professional and industry needs.

CO2: Collaborate on various writing projects for academic and technical purposes.

CO3: Combine attributes of critical thinking for improving technical documentation.

CO4: Adapt technical writing styles to different platforms.

Technical Communication

Process(es) and Types of Speaking and Writing for Professional Purposes - Technical Writing: Introduction, Definition, Scope and Characteristics - Audience Analysis - Conciseness and Coherences - Critical Thinking - Accuracy and Reliability - Ethical Consideration in Writing - Presentation Skills - Professional Grooming - Poster Presentations

Grammar, Punctuation and Stylistics

Constituent Structure of Sentences - Functional Roles of Elements in a Sentence - Thematic Structures and Interpretations - Clarity - Verb Tense and Mood - Active and Passive Structures - Reporting Verbs and Reported Tense - Formatting of Technical Documents - Incorporating Visuals Elements - Proofreading

Technical Documentation

Types of Technical Documents: Reports, Proposals, Cover Letters - Manuals and Instructions - Online Documentation - Product Documentation - Collaborative Writing: Tools and Software - Version Control Document Management - Self Editing, Peer Review and Feedback Processes

References:

1. Foley, M., & Hall, D. Longman advanced learner's grammar, a self-study reference & practice book with answers. Pearson Education Limited, 2018.
2. Gerson, S. J., & Gerson, S. M., Technical writing: Process and product. Pearson, 2009.
3. Kirkwood, H. M. A., & M., M. C. M. I., Hallidays introduction to functional grammar (4th ed.). Hodder Education, 2013.
4. Markel, M.,Technical Communication (10th ed.). Palgrave Macmillan, 2012.
5. Tuhovsky, I.,Communication skills training: A practical guide to improving your social intelligence, presentation, Persuasion and public speaking skills. Rupa Publications India, 2019.
6. Williams, R. The Non-designer's Design Book. Peachpit Press, 2014.

ZZ6002E RESEARCH METHODOLOGY

Pre-requisites: Nil

L	T	P	O	C
2	1	0	4	2

Total Lecture sessions: 26

Course Outcomes
CO1: Explain the basic concepts and types of research.
CO2: Develop research design and techniques of data analysis
CO3: Present research to the scientific community
CO4: Develop an understanding of the ethical dimensions of conducting research.

Exploring Research Inquisitiveness
Philosophy of Scientific Research, Role of Research Guide, Planning the Research Project, Research Process, Research Problem Identification and Formulation, Variables, Framework development, Research Design, Types of Research, Sampling, Measurement, Validity and Reliability, Survey, Designing Experiments, Research Proposal, Research Communication, Research Publication, Structuring a research paper, structuring thesis/ dissertation.

Data Analysis
Literature review: Tools and Techniques, Collection and presentation of data, processing and analysis of data, Descriptive statistics and inferential statistics, Measures of central tendency, dispersion, skewness, asymmetry, Probability distributions, Single population and two population hypothesis testing, Parametric and non-parametric tests, Design and analysis of experiments: Analysis of Variance (ANOVA), completely randomized design, Measures of relationship: Correlation and regression, simple regression analysis, multiple regression, interpretation of results, Heuristics and simulation.

Research writing and Ethics
Reporting and presenting research, Paper title and keywords, writing an abstract, writing the different sections of a paper, revising a paper, responding to peer reviews.

The codes of ethics, copyright, patents, intellectual property rights, plagiarism, citation, acknowledgement, avoiding the problems of biased survey.

References:
1. Krishnaswamy, K.N., Sivakumar, A.I., and Mathirajan, M., Management Research Methodology, Pearson Education, 2006.
2. Leedy, P, D. Practical Research: Planning and Design (12 e) Pearson, 2018.
3. Kothari, C.R. Research Methodology – Methods and Techniques, New Age International Publishers, 2004..
4. Martin, M. and Schinzinger, R., Ethics in Engineering, Mc Graw Hill Education, 2004.
5. Sople, V. V., Managing Intellectual Property-The Strategic Imperative, EDA Prentice of Hall Pvt. Ltd.