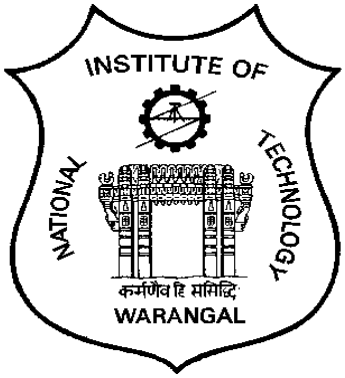
NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL



RULES AND REGULATIONS
SCHEME OF INSTRUCTION AND SYLLABI
FOR M.TECH PROGRAM in
TRANSPORTATION ENGINEERING

Effective from Academic Year: 2016-17

DEPARTMENT OF CIVIL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
WARANGAL – 506004 TELANGANA
July 2016

NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

VISION

Towards a global knowledge hub, striving continuously in pursuit of excellence in education, research, entrepreneurship and technological services to the society.

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

DEPARTMENT OF CIVIL ENGINEERING

VISION

To be a knowledge nerve centre in civil engineering education, research, entrepreneurship and industry outreach services for creating sustainable infrastructure and enhancing quality of life.

MISSION

- Generate a specialized cadre of civil engineers by imparting quality education and training.
- Attain international standards in teaching, research and consultancy with global linkages.

NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL
DEPARTMENT OF CIVIL ENGINEERING

M.Tech. Program in TRANSPORTATION ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

The graduating students of the Transportation Engineering programme will be able to:

PEO1.	Plan, design, construct, operate and maintain safe, cost effective and sustainable transportation systems in the context of environmental, economic and social requirements.
PEO2.	Become globally competent professionals to fit into a broad range of career opportunities available in transportation industry, research, government and other fields.
PEO3.	Demonstrate good communication and management skills, and leadership qualities to work effectively and lead interdisciplinary teams in rapidly changing and diverse workplaces.
PEO4.	Engage in lifelong learning by participating in technical events, conferences, workshops, seminars, events of professional societies, and allied activities for both personal development and career growth.
PEO5.	Execute complex transportation projects and evaluate their impact on the society with an understanding of professional ethics and social responsibility.

PROGRAM OUTCOMES (POs)

At the end of the program the graduate will be able to:

PO1	Apply knowledge of basic science, engineering and optimization techniques to transportation engineering problems.
PO2	Plan, critically analyze, design, synthesize and execute complex transportation engineering infrastructure projects.
PO3	Offer sustainable engineered solutions for transportation related societal problems like urban and regional network planning in local and global context.
PO4	Initiate research investigations in an attempt to find feasible and sustainable solutions to problems encountered by the society and offer the same to urban, state and national transportation authorities for effective implementation.
PO5	Function as a member of an interdisciplinary team and assume a leadership role in executing projects of multidisciplinary nature.
PO6	Recognize the need for and engage in lifelong learning.
PO7	Turn out to be an entrepreneur and generate employment and provide cost effective solutions.
PO8	Prepare quality control and quality assurance plans to manage transportation infrastructure projects economically.
PO9	Develop innovative green technologies related to transportation for sustainable growth.
PO10	Perform the assigned duties with good professional and ethical responsibility.

SCHEME OF INSTRUCTION AND EVALUATION

M.Tech. (Transportation Engineering): Course Structure

I Year M. Tech. (T.E.) I – Semester

Sl. No.	Course Code	Course Title	L	T	P	C
1	CE5601	Urban Transportation Planning	4	0	0	4
2	CE5602	Traffic Analysis	4	0	0	4
3	CE5603	Pavement Analysis and Design	4	0	0	4
4		Elective – I	3	0	0	3
5		Elective – II	3	0	0	3
6		Elective – III	3	0	0	3
7	CE5604	Traffic Measurements Laboratory	0	0	3	2
8	CE5605	Computational Laboratory	0	0	3	2
9	CE5641	Seminar-I	0	0	2	1
		TOTAL	**21**	**0**	**8**	**26**

List of Elective Courses in I Year I Semester (Electives I, II and III)

Sl. No.	Course Code	Course Title
1	CE5611	Advanced Pavement Materials
2	CE5612	Crash Reduction and Prevention
3	CE5613	Environmental Analysis of Transportation Systems
4	CE5614	Freight Transportation Planning
5	CE5615	Low Volume Roads
6	CE5616	Railway Infrastructure Planning and Design
7	CE5617	Sustainable Transportation
8	CE5618	Traffic Control and Management
9	CE5619	Transport Policy and Financing
10	CE5620	Transportation Data Analysis
11	CE5621	Transportation System Management
12	CE5622	Waterway Infrastructure Planning and Design

In addition to the above courses, students are permitted to take elective courses of other specializations in the department.

I Year M. Tech. (T.E.) II – Semester

Sl. No.	Course Code	Course Title	L	T	P	C
1	CE5651	Advanced Travel Demand Modeling	4	0	0	4
2	CE5652	Traffic Systems Design	4	0	0	4
3	CE5653	Pavement Construction and Evaluation	4	0	0	4
4		Elective – IV	3	0	0	3
5		Elective – V	3	0	0	3
6		Elective – VI	3	0	0	3
7	CE5654	Pavement Materials and Evaluation Laboratory	0	0	3	2
8	CE5655	Transportation Engineering Software Laboratory	0	0	3	2
9	CE5691	Seminar – II	0	0	2	1
		TOTAL	**21**	**0**	**8**	**26**

List of Elective Courses in I Year II Semester (Electives IV, V and VI)*

Sl. No.	Course Code	Course Title
1	CE5661	Airport Infrastructure Planning and Design
2	CE5662	GIS for Transportation
3	CE5663	Intelligent Transportation Systems
4	CE5664	Transport Logistics
5	CE5665	Optimization Techniques in Transportation
6	CE5666	Pavement Management System
7	CE5667	Public Transportation
8	CE5668	Regional Transportation Planning
9	CE5669	Road Asset Management
10	CE5670	Traffic Flow Modeling and Simulation
11	CE5671	Transport Economics and Project Appraisal
12	CE5672	Transportation Network Analysis

*In addition to the above courses, students are permitted to take elective courses of other specializations in the department.

Sl. No.	Course Code	Course Title	Credits
		II Year M. Tech. (T.E.) I – Semester	
1		Industrial Training (8-10 weeks) Optional	
2	CE6642	Comprehensive Viva Voce	2
3	CE6649	Dissertation Part – A	6
		II Year M. Tech. (T.E.) II – Semester	
4	CE6699	Dissertation Part – B	12

Sl. No.	Courses	No. of Courses Offered					Credits
		I Sem.	II Sem.	III Sem.	IV Sem.	Total	
A	**Core Courses (≥30 credits)**						
1.	Theory courses	3	3	-	-	6	24
2.	Laboratory Courses	2	2	-	-	4	8
3.	Seminars	1	1	-	-	2	2
4.	Comprehensive Viva Voce	-	-	1	-	1	2
	Sub Total	**6**	**6**	**1**	**-**	**13**	**36**
B	**Elective courses (≥15 credits)**	**3**	**3**	**-**	**-**	**6**	**18**
C	**Dissertation (= 18 credits)**	**-**	**-**	**1**	**1**	**2**	**18**
	Grand Total	**9**	**9**	**2**	**1**	**21**	**72**

DETAILED SYLLABUS FOR EACH COURSE

M.Tech. (Transportation Engineering) I Semester

CE5601: URBAN TRANSPORTATION PLANNING
Course Type: Core; Instruction: L-T-P-C: 4-0-0-4

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Distinguish various Urban Forms and Structures and Identify urban transportation problems
CO2	Estimate urban travel demand.
CO3	Plan urban transport networks.
CO4	Develop land use transportation models
CO5	Identify urban transport corridors and Prepare urban transportation plans.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	*1*		*3*	*2*		*1*				
CO2	*3*	*2*		*3*		*1*				
CO3	*2*	*3*	*3*							*1*
CO4	*1*									*1*
CO5	*1*	*3*	*2*						*1*	*1*

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Urban Forms and Structures:
Urbanisation and Migration, Findings of Commission on Urbanisation, Urban forms: Garden City, Linear city, Radburn, Urban Neighborhood, Precinct, MARS, Le Corbusier, Collin Buchanan, etc. Urban structures: Centripetal type, Grid type, linear type and directional grid type, Evolution of spatial structure.

Urban Transportation Problems and Policy:
Urban transportation Issues, Travel Characteristics, Evolution of Planning Process, Supply and Demand – Systems approach; NUTP, Recommendations of 12th FYP and NTDP

Travel demand:
Trends, Overall Planning process, Long term Vs Short term planning, Demand Function, Independent Variables, Travel Attributes, Assumptions in Demand Estimation, Sequential, and Simultaneous Approaches, Aggregate and Disaggregate Techniques.

Data collection and inventories:
Collection of data – Organisation of surveys and Analysis, Study Area, Zoning, Types and Sources of Data, Road Side Interviews, Home Interview Surveys, Commercial Vehicle Surveys, Sampling Techniques, Expansion Factors, Accuracy Checks, Use of Secondary Sources, Economic data – Income – Population – Employment – Vehicle Owner Ship.

Trip Generation and Distribution:
UTPS Approach, Trip Generation Analysis: Zonal Models, Category Analysis, Household Models, Trip Attraction models, Commercial Trip Rates; Trip Distribution: Growth Factor Methods, Gravity Models, Opportunity Models, Time Function Iteration Models.

Mode Split and Traffic Assignment:
Mode Choice Behaviour, Competing Modes, Mode Split Curves, Models and Probabilistic Approaches; Traffic Assignment: Basic Elements of Transport Networks, Coding, Route Properties, Path Building Criteria, Skimming Tree, All-or-Nothing Assignment, Capacity Restraint Techniques, Reallocation of Assigned Volumes, Equilibrium Assignment, Diversion Curves.

Land Use – Transportation Models:
Concentric urban land use model, Sector land use model, multiple nuclei land use model, hybrid land use models, Cellular automata models, and land rent theory; Urban regions. Land use – Transportation Interactions; Classification of LUT Models, Economic Base Mechanism, Allocation Mechanism and Spatial Allocation and Employment Relationships, Garin Lowry Models

Corridor Identification - Plan preparation and evaluation:
Master plans, Selection of Corridor, Corridor Identification, Corridor deficiency Analysis; TOD; Travel Forecasts to Evaluate Alternative Improvements, Impacts of New Development on Transportation Facilities; Pivot Point Analysis, Environmental and Energy Analysis.

READING:

1. Bruton, M. J., An Introduction to Transportation Planning (The Living Environment), UCL Press, London, UK, 2000.
2. C. Jotin Khisty and B. Kent Lall, Transportation Engineering: An Introduction, 3rd Edition, Prentice Hall of India Pvt. Ltd., 2003.
3. C.S. Papacostas and Panos D. Prevedouros, Transportation Engineering and Planning, Prentice Hall of India Pvt. Ltd., 2001.
4. Hutchinson, B.G., Principles of Urban Transport Systems Planning, McGraw Hill, 1974.
5. Institute of Transportation Engineers (Michael D. Meyer Editor), Transportation Planning Handbook, Fourth Edition, John Wiley & Sons, Inc., New Jersey, 2016.
6. Juan de Dios Ortuzar and Luis G. Willumsen, *Modelling Transport, 4th Edition*, John Wiley and Sons, New York 2011.
7. Michael D. Meyer and Eric J. Miller, Urban Transportation Planning: A decision oriented Approach, Second Edition, McGraw Hill, 2001.

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CE5602: TRAFFIC ANALYSIS
Course Type: Core; Instruction: L-T-P-C: 4-0-0-4

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Estimate basic characteristics of traffic stream.
CO2	Conduct traffic studies and analyze traffic data.
CO3	Model traffic stream behavior.
CO4	Determine the capacity of highways.
CO5	Analyze the traffic data and interpret the results.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2		1			2	2	2	2
CO2	2	3	2	3			2	2	1	2
CO3	3	3	3	2			2	2	2	2
CO4	1	3	3	2	2		1	2	3	2
CO5	3	2		1	2		2	2	2	2

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Components of Traffic System:
Introduction, Human-vehicle-environment system, Characteristics of road users, characteristics of vehicles, Characteristics of Pedestrians.

Characteristics of Traffic:
Fundamental parameters of traffic and relationships; Time headways, temporal, spatial and flow patterns; Interrupted and un-interrupted traffic; Microscopic and macroscopic speed characteristics; Vehicular speed trajectories; Speed characteristics- mathematical distributions; Speed and travel time variations.

Traffic Data Collection studies:
Traffic study components, types of data; Volume studies; Speed studies; Travel time and delay studies; Intersection studies, Pedestrian studies; Parking studies, Vehicle detection methods; Advanced methods: GPS, Instrumented Vehicles, Image Processing, Bluetooth, Infrared methods, Sample selection; Region traffic counts; Growth factors.

Macroscopic Traffic Stream Models:
Stream flow fundamentals; family of models, Hydrodynamic and Kinematic Analysis of Traffic: Continuity equation; Waves in traffic, Traffic fluid state considerations, Continuity equation; Waves in traffic, Traffic fluid state considerations; Platoon diffusion.

Microscopic Traffic Stream Models:
Car-following: Stimulus-response; Distance based models; Gap acceptance models; Mixed traffic flow behaviour: Non-lane based movement, Heterogeneity, Applications.

Highway Capacity Analysis:
Capacity and level of service concepts; Factors affecting capacity and LOS; Freeway and multi-lane analysis; Capacity of Urban arterials; Signalised intersections; Un-signalised intersections; US Highway Capacity Manual (HCM) and IRC standards, Indo-HCM standards.

READING:

1. Adolf D. May, Traffic Flow Fundamentals, Prentice Hall, 1990.
2. C. Jotin Khisty , B. Kent Lall, Transportation Engineering: An Introduction, Prentice Hall; 3rd Edition, 2003.
3. Chakroborty Partha, Das Animesh, Principles of Transportation Engineering, PHI Learning Pvt. Ltd., 1st Edition, 2009.
4. Fred L. Mannering, Scott S. Washburn, Kilareski Walter P., Principles Of Highway Engineering And Traffic Analysis, Wiley India Pvt Ltd., 4th Edition, 2011.
5. L.R. Kadiyali, Traffic Engineering and Transportation Planning, Khanna Publishers, 2011.
6. Louis J. Pignataro and Edmund J. Cantilli, Traffic Engineering: Theory and Practice; Prentice hall, Inc., 1973
7. Mike Slinn, Paul Matthews, Peter Guest, Traffic Engineering Design: Principles and Practice, Butterworth-heinemann, 2nd Edition, 2005.
8. Nicholas J. Garber, Lester A. Hoel, Nicholas J. Garber, Lester A. Hoel, Principles of Traffic and Highway Engineering, Cengage Learning India, 2nd Edition, 2010.
9. Roger P. Roess, Elena S. Prassas and William R. McShane, Traffic Engineering, Prentice Hall, 4th Edition, 2010.
10. TRB Highway Capacity Manual, Transportation Research Board, Washington, D.C., 2010.

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CE5603: PAVEMENT ANALYSIS AND DESIGN
Course Type: Core; Instruction: L-T-P-C: 4-0-0-4

Pre Requisite Courses: NIL

Course Outcomes: *At the end of the course, students will be able to*

CO1	Analyze the stresses and strains in a flexible pavement using multi-layered elastic theory, and the KENLAYER program.
CO2	Analyze stresses and strains in a rigid pavement using Westergaard's theory, and the KENSLABS program.
CO3	Design a flexible pavement using IRC, Asphalt Institute, and AASHTO methods.
CO4	Design a rigid pavement using IRC and AASHTO methods.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	3			1			2
CO2	3	3	3	3			1			2
CO3	3	3	3	3			1			2
CO4	3	3	3	3			1			2

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

1. **Pavement Types and Materials:**
   Types and component parts of pavements; highway and airport pavements.
   Basic characteristics of materials used in pavements.

2. **Stresses in Flexible Pavements**:
   Layered system concepts.
   Stress solution for one, two and three layered systems.
   Fundamental design concepts.
   Stress analysis in flexible pavements using KENLAYER.

3. **Stresses in Rigid Pavements:**
   Westergaard's theory and assumptions.
   Stresses due to curling, stresses and deflections due to loading, frictional stresses.
   Stresses in dowel bars and tie bars.
   Stress analysis in rigid pavements using KENSLABS.

4. **Factors Affecting Pavement Design:**
   Variables considered in pavement design.
   Classification of axle types, standard and legal axle loads, tyre pressure, contact pressure, ESWL, EWLF and EAL concepts.
   Traffic analysis: ADT, AADT, truck factor, growth factor, lane distribution factor, directional distribution factor and vehicle damage factor.

5. **Design of Flexible Pavements:**
   IRC method of flexible pavement design.
   Asphalt Institute's methods with HMA and other base combinations.
   AASHTO method of flexible pavement design.
   Design of flexible pavement shoulders.

6. **Design of Rigid Pavements**:
   IRC method of plain jointed and continuously reinforced rigid pavement design.
   AASHTO method of rigid pavement design.

Design of rigid pavement shoulders.

7. **Design of Pavement Drainage**
   Detrimental effects of water, methods for controlling water in pavements.
   Drainage materials: aggregates, geotextiles, pipes.
   Estimation of inflow, determination of drainage capacity.

READING:

1) **Asphalt Institute.** *Thickness Design – Asphalt Pavements for Highways and Streets Manual Series No. 1 (MS-1)*, Asphalt Institute, Kentucky, USA, 1999.
2) **Das, A.** *Analysis of Pavement Structures*, CRC Press, Taylor and Francis Group, Florida, USA, 2015.
3) **Huang, Y.H.** *Pavement Analysis and Design*, Second Edition, Dorling Kindersley (India) Pvt. Ltd., New Delhi, India, 2008.
4) **IRC: 37-2012** *Guidelines for the Design of Flexible Pavements*, The Indian Roads Congress, New Delhi, India, 2012.
5) **IRC:58-2015** *Guidelines for the Design of Plain Jointed Rigid Pavements for Highways*, The Indian Roads Congress, New Delhi, India, 2015.
6) **Mallick, R.B.** and **T. El-Korchi** *Pavement Engineering – Principles and Practice*, CRC Press, Taylor and Francis Group, Florida, USA, 2009.
7) **MEPDG-1.** *Mechanistic-Empirical Pavement Design Guide - A Manual of Practice*, Interim Edition, American Association of State Highway and Transportation Officials, Washington, D.C., USA, 2008.
8) **Papagiannakis, A.T.** and **E.A. Masad** *Pavement Design and Materials*, John Wiley and Sons, New Jersey, USA, 2008.
9) **Yoder, E.J.** and **M.W. Witczak** *Principles of Pavement Design*, Second Edition, John Wiley and Sons, New York, USA, 1975.

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CE5604: TRAFFIC MEASUREMENTS LABORATORY
Course Type: Core; Instruction: L-T-P-C: 0-0-3-2

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Conduct traffic studies for estimating traffic flow characteristics.
CO2	Determine the capacity and level of service of a highway element.
CO3	Estimate parking requirements and inventory analysis.
CO4	Design traffic signal systems.
CO5	Determine causative analysis of delays.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3				3					3
CO2	2	3	3	3	3			2	2	3
CO3	3	3	3	3	3		2			3
CO4	2	3	3	2	3		3	3		3
CO5	2	3	3	3	3		2	3	2	3

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Volume studies:
Direction, Duration and Classification of Traffic Volume at Mid-Block Section and Intersections, Manual, and Mechanical Methods, Headway Distributions

Speed studies:
Spot Speed Studies - Radar Speed Meters

Journey time and delay studies:
Travel Time and Delay Studies by Floating Car Method

Gap acceptance studies:
Study of Gaps, Lags, Critical Gaps at Intersections

Intersection delay studies:
Delay Measurement at Uncontrolled Intersections and Signalised Intersections

Parking surveys:
Parking Inventory and Turnover Studies

Measurement of driver characteristics:
Reaction Testing, Action Judgement Testing, Driver Vision Testing, Discriminative Reaction Testing, Evaluation of driver Knowledge – Traffic Rules – Road Signs & Markings – Traffic Signs and Motor Vehicle Act Relevant clauses

Highway Capacity Estimation:
Videographic method, Dynamic PCU

READING:

1. C. Jotin Khisty and, B. Kent Lall, Transportation Engineering: An Introduction, Prentice Hall; 3rd Edition, 2002.
2. Currin, Introduction to Traffic Engineering: Manual F/data Collect & Analysis, CL Engineering, 2nd Edition, 2012.

3. L.R. Kadiyali, Traffic Engineering and Transportation Planning, Khanna Publishers, 2011.
4. Pignataro LJ. Traffic Engineering: Theory and Practice; Prentice hall, Inc, 1973
5. Roger P. Roess, Elena S. Prassas and William R. McShane, Traffic Engineering, Prentice Hall, 4th Edition, 2010.

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CE5605: COMPUTATIONAL LABORATORY
Course Type: Core; Instruction: L-T-P-C: 0-0-3-2

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Understand the data types, sampling and choice of method to evaluate.
CO2	Perform data analysis and interpretation using programming tools and packages.
CO3	Perform statistical significance tests and derive conclusions from the results.
CO4	Construct statistical relationships and carryout validation from actual data.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2			1					1
CO2	3	2		1	1	1				1
CO3	3	2		2	1	1				1
CO4	2	3	3	2	1	1	1		1	1

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Data presentation

Exercise for measuring central tendency, dispersion and shape of data, graphical representation, plots and pattern, interpretation of results, and histograms by using MS office tools and other statistical packages.

Data sampling and description

Sampling exercises, data storing, handling, cleaning, and descriptive analysis exercises by using MS assess, excel and statistical tools.

Data Analysis and statistical inference

Exercise for fitting probabilistic distributions, correlation analysis, simple linear and multiple linear regressions, nonlinear regression, parametric and non-parametric tests, test of significance, paired and unpaired sample tests and evaluation, analysis of variance, univariate and multivariate analysis, time series analysis, data analysis with MS excel and statistical package.

Basics of Programming for data analysis:

R programming for statistical analysis and probability studies, applications of C++ /Java, Codeskulptor, python etc.

READING:

1. Bovas A., N. Nair U., *Quality Improvement through Statistical Method*, Springer Science & Business Media, 01-Aug-1998.
2. Clifford S., E. S. Park, Laurence R. R., *Transportation Statistics and Microsimulation*, CRC Press, Taylor and Francis group, 2011.
3. Dewhurst, Stephen C., *C++ Common Knowledge: Essential Intermediate Programming*, Addison-Wesley, 2005.
4. John C., *Software for Data Analysis: Programming with R*, Stanford University, Springer, 2008.
5. John G., *Introduction to Computation and Programming Using Python*, MIT, Press book, 2013.

6. Robert V. Hogg, and E. Tanis A., *Probability and Statistical Inference*, 6th Edition, Prentice Hall, 2000
7. Simon P. Washington, Matthew G. Karlaftis, Fred, Mannering L., *Statistical and Econometric Methods for Transportation Data Analysis*, CRC Press, Second Edition, 2010.

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CE5641: SEMINAR – I
Course Type: Core; Instruction: L-T-P-C: 0-0-2-1

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Identify and chose appropriate topic of relevance.
CO2	Assimilate literature on technical articles of specified topic and develop comprehension.
CO3	Write technical report.
CO4	*Design and develop presentation on a given technical topic.*
CO5	*Deliver technical presentation on a specified topic.*

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		1	1	1		2				1
CO2		2	2	2		2				1
CO3		2				2				1
CO4		2			1	2				1
CO5		1	1		1					

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

There is no specific syllabus for this course. However, student can choose any topic, of his choice, pertaining to Transportation Engineering. Topic should be a relevant and currently researched one. Students are advised to refer articles published in current journals in the area of Transportation Engineering for choosing their seminar topics. Student should review minimum of 5 to 6 research papers relevant to the topic chosen, in addition to standard textbooks, handbooks, etc. Students are required to prepare a seminar report, in the standard format and give presentation to the Seminar Assessment Committee (SAC) in the presence of their classmates. It is mandatory for all the students to attend the presentations of their classmates.

READING:

1. Guidelines for the Preparation and Delivery of a Seminar Presentation: http://www2.cs.uregina.ca/~hilder/cs499-900/Presentation%20Guidelines.pdf
2. Guidelines on Seminar Presentation: http://foodsci.rutgers.edu/gsa/SeminarGaudelines.pdf
3. Instructor Resources: Seminar Proposal Guidelines, SAE International; http://www.sae.org/training/seminars/instructorzone/proposalguidelines.pdf
4. Research Articles / Reports available on Internet
5. Transportation Engineering Journals
6. Transportation Engineering Textbooks and Handbooks

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CE5611: ADVANCED PAVEMENT MATERIALS
Course Type: Elective; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses: NIL

Course Outcomes: *At the end of the course, students will be able to*

CO1	Determine the proportions of ingredients required for the mix design of both asphalt mixtures and cement concrete.
CO2	Characterize the pavement materials including soil, aggregate, asphalt, cement, asphalt mixtures, cement concrete.
CO3	Select appropriate asphalt binder for construction of a flexible pavement depending upon the traffic and climatic conditions.
CO4	Choose appropriate stabilization technique for pavement applications.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	3			1			3
CO2	3	3	3	3			1		3	3
CO3	3	3	3	3			1		3	
CO4		3	3	3			1		3	

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

1 **General**:
Materials used in pavement construction.
Conventional and nonconventional materials.

2 **Aggregate:**
Physical and mechanical properties of aggregates.
Blending of aggregate.
Alternate materials for conventional aggregates including natural, manufactured, industrial by-products, and waste materials.

3 **Bituminous Binders:**
Types of bituminous binders including unmodified bitumen, modified bitumen (crumb rubber modified bitumen, polymer modified bitumen), bitumen emulsion, and cutback bitumen.
Tests on bitumen, physical properties, specifications for paving bitumen.
Rheology of bituminous binders: Newtonian and non-Newtonian fluids.
Grading of bitumen: penetration, viscosity, and performance grading.
Introduction to linear viscoelasticity: creep and recovery; stress relaxation; mechanical models to describe viscoelastic response including Maxwell element, Voigt-Kelvin element, standard linear solid element, Burger's element.
Dynamic response to sinusoidal loading of viscoelastic materials, energy storage and dissipation.
Time-temperature superposition, construction of master curves.

Check for linear scaling and superposition of separate responses.

4 **Bituminous Mixes:**
Design of bituminous mixes using Marshall method, and SUPERPAVE method.
Types of bituminous mixes including hot mixes, cold mixes, warm mixes and applications.
Permanent deformation, dynamic modulus, fatigue of bituminous mixes, moisture induced damage in bituminous mixes.

5 **Cement and Cement Concrete:**
Cement: chemical composition, types, physical properties, admixtures.
Physical properties of cement concrete related to pavement applications.
Design of cement concrete mixes for pavements.
Special types of cement concrete: polymer concrete composites, sulphur concrete composites, fibre reinforced concrete, ferrocement, roller compacted concrete, and high strength concrete.

8. **Granular Materials:**
Basic soil properties relevant to pavement applications.
Resilient modulus of granular materials, modulus of subgrade reaction.

7 **Stabilization:**
Soil stabilization: use of lime, cement, bitumen, and other commercial stabilizers.
Applications of geosynthetics in pavements.

READING:

1. **Asphalt Institute.** *Asphalt Mix Design Methods*, *Manual Series No. 2 (MS-2)*, Seventh Edition, Asphalt Institute, Kentucky, USA, 2014.
2. **Huang, Y.H.** *Pavement Analysis and Design*, Pearson Prentice Hall, New Jersey, USA, 2004.
3. **IRC: 44-2008** *Guidelines for Cement Concrete Mix Design for Pavements*, the Indian Roads Congress, New Delhi, India, 2008.
4. **Kandhal, P.S.** *Bituminous Road Construction in India*, PHI Learning Pvt. Ltd., New Delhi, India, 2016.
5. **Mallick, R.B.** and **T. El-Korchi** *Pavement Engineering – Principles and Practice*, CRC Press, Taylor and Francis Group, Florida, USA, 2009.
6. **Ministry of Road Transport and Highways.** *Specifications for Road and Bridge Works*, Fifth Edition, Indian Roads Congress, New Delhi, India, 2013.
7. **Papagiannakis, A.T.** and **E.A. Masad** *Pavement Design and Materials*, John Wiley and Sons, New Jersey, USA, 2008.
8. **Richard M. Christensen,** *Theory of Viscoelasticity, Second Edition,* Dover Publications, Inc, New York, USA, 1982.
9. **Sherwood, P.T.** *Alternative materials in road construction*, Thomas Telford, New York, USA, 1997.

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CE5612: CRASH REDUCTION AND PREVENTION
Course Type: Elective; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Analyze the effect of driver characteristics, roadway characteristics, and climatic factors on safety.
CO2	Plan and design of road safety improvement programs.
CO3	Analyze accident data and suggest safety measures.
CO4	Conduct road safety audit.
CO5	Interpret accident data using statistical analysis.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2	3	3	3						2
CO2	3	3	3	2	2	1	2	2	2	3
CO3	3	3	3	3	2		2	2		3
CO4	2	3	3	3	2	1		2		3
CO5	3	3	2	2	2			2		2

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Introduction to safety:
Road accidents, Trends, causes, Collision diagrams; Highway safety; Human factors and road user limitations; Speed and its effect on road safety; Vehicle factors; Highway safety in India.

Road Safety Management System:
Multi-causal dynamic systems approach to safety; Crash Vs Accident; Road safety improvement strategies; Elements of a road safety plan, Safety data Needs; Safe vehicle design.

Statistical Interpretation and Analysis of Crash Data:
Before-after methods in crash analysis, Recording of crash data; Accident Investigation and Analysis; Statistical testing and the role of chance; Black Spot Identification and Investigations, Case Studies.

Road Safety Audits:
Key elements of a road safety audit, Road Safety Audits & Investigations, Work zone safety audit; Crash investigation and analysis, Methods for identifying hazardous road locations, Case Studies.

Crash Reconstruction:
Describe the basic information that can be obtained from the roadway surface, Understand basic physics related to crash reconstruction, speed for various skid, friction, drag, and acceleration scenarios, variables involved in jump and flip crashes, variables involved in pedestrian crashes, Case Studies.

Mitigation Measures:
Accident prevention by better planning, Accident prevention by better design of roads, Crash Countermeasures, Highway operation and accident control measures, Highway Safety Measures during construction, Highway geometry and safety; Safety in urban areas; Public transport and safety; Road safety policy making, Stakeholders involvement; Road safety law.

READING:

1. Athelstan Popkess, Traffic Control and Road Accident Prevention, Chapman and Hall, 1997 (Digitized 2008)
2. Ezra Hauer, Observational Before-After Studies in Road Safety, Pergamon Press, 1997 (reprinted 2002).
3. Geetam Tiwari and Dinesh Mohan, Transport Planning and Traffic Safety: Making Cities, Roads, and Vehicles Safer, CRC Press, 2016.
4. Institute of Transportation Engineers (ITE), The Traffic Safety Toolbox: A Primer on Traffic Safety, ITE, 1999.
5. J. Stannard Baker, Traffic Collision Investigation, Northwestern University Center for Public Safety, 2002.
6. Ken W. Ogden, Safer Roads: A Guide to Road Safety Engineering. Avebury Technical, 1996.
7. Leonard Evans, Traffic Safety, Science Serving Society, 2004.
8. Lynn B. Fricke, Traffic Crash Reconstruction, Second Edition, Northwestern University Center for Public Safety, 2010.
9. Rune Elvik and Truls Vaa, The Handbook of Road Safety Measures, Elsevier, 2004.
10. Towards Safe Roads in Developing country, TRL – ODA, 2004.

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CE5613: ENVIRONMENTAL ANALYSIS OF TRANSPORTATION SYSTEMS
Course Type: Elective; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Describe the need for studying the effects of transportation systems on the environment.
CO2	Estimate air pollution and noise pollution caused by a transportation system.
CO3	Describe the EIA study and its process.
CO4	Apply different methods to carry out an EIA study.
CO5	Perform measures to mitigate air pollution and noise pollution caused by a transportation system.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		2			1					
CO2	3	3			2				1	
CO3	2	2			2					2
CO4	3	2			1					
CO5		2	2	2					2	1

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Introduction:
Environment and its interaction with human activities – Air and Noise Pollution due to Transportation, Environmental imbalances - Attributes, Impacts, Indicators and Measurements - Concept of Environmental Impact Assessment (EIA), Environmental Impact Statement (EIS)

Environmental Standards, Laws & Regulations:
Laws concerned with protection of the environment such as Environmental Protection Act, Air and Noise Pollution Act, Motor Vehicle Act, Town and Country Planning Act, Development Control Regulation

Prediction of Air & Noise Pollution:
Factors affecting air pollution from road traffic - Vehicle characteristics, Engine types, Vehicle age and maintenance, Driving conditions, Average speed, Temperature, Meteorological conditions; Emission inventory; Dispersion of pollutants; Inverse air quality models; Emission and dispersion models; Driving cycles; Macroscopic and Microscopic modeling at the microscopic level of air pollution from road traffic; Road traffic noise model (RTNM), Calixto model, Acoustical assessment.

Environmental Impact Assessment and Statement (EIA & EIS):
Objectives of EIA, Advantages and Limitations of EIA; Overview of Methodologies Adhoc, Checklist, Matrix, Network, Overlays, Benefit Cost Analysis, Choosing a Methodology, Review Criteria; IRC Code

Mitigation Measures & Policies:
Cleaner fuels, Vehicle technology and replacement strategies, Improving fuel efficiency, Encouraging non-motorised and public transport, Taxation on emissions; Noise barriers, Land use planning, Resurfacing roads with low-noise materials, Managing traffic flows, advanced construction methods.

READING:

1. Canter, L.W., Environmental Impact Assessment, McGraw Hill Pub. Co., New York, 1997
2. David Banister; Transport Policy and Environment, E&FN Spain, 1999
3. Keith W. Little, Environmental Fate and Transport Analysis with Compartment Modeling, CRC Press, Taylor & Francis Group, 2012.
4. Louis Franklin Cohen and Gary Richard McVoy, Environmental Analysis of Transportation Systems, John Wiley & Sons, 1982
5. NCHRP Report 541. Consideration of Environmental Factors in Transportation Systems Planning, TRB, 2005.
6. NCHRP Synthesis 272, Best Management Practices for Environmental Issues Related to Highway and Street Maintenance: A Synthesis of Highway Practice, National Research Council, TRB, 1999.
7. Peter Morris and Riki Therivel, Methods of Environmental Impact Assessment (Natural and Built Environment Series), 3rd Edition, Routledge, 2009
8. TRB Special Report 268. Surface Transportation Environmental Research: A Long-Term Strategy, National Academies Press, 2005 (http://www.nap.edu/catalog/10354.html)
9. World Bank; the Impact of Environmental Assessment – A Review of World Bank Experience, Washington, 1997.
10. World Bank; Road and the Environment, Washington, 1997.

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CE5614: FREIGHT TRANSPORTATION PLANNING
Course Type: Elective; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Identify issues in Freight Transportation.
CO2	Estimate Freight Demand.
CO3	Assess safety and environmental implications due to freight transport.
CO4	Estimate requirements of intermodal freight transport.
CO5	Identify appropriate ITS tools for enhancing efficiency of Freight Travel.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		1	1	1						
CO2	3	3		1		1				
CO3		1	1		1					
CO4		1	1		1					
CO5		1	1	2					1	

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Introduction:
Freight Characteristics, Factors influencing Freight Travel, operators, problems in freight transportation, regional vs. urban goods travel, intermodal freight travel issues.

Freight Demand Estimation:
Operations, Planning - purpose, process, Data, Freight Agents, costs, Planning Models and Methods-freight demand estimation and forecasting at regional and urban level, IO model, Freight flow on the network, Performance, Case studies.

Freight Transport Planning and Operations:
Freight supply – capacity issues; freight productivity and performance; freight impacts – safety and environmental issues; route planning and scheduling, collection storage and distribution centers, regulation and enforcement of freight transport.

Intermodal Freight Transport:
Rail freight operations, Intermodal Networks and Freight Interchanges, Intermodal Road and Rail Vehicles and Maritime Vessels; Air freight; intermodal freight terminals

ITS for Freight Transport:
Introduction to ITS, Role of ITS, ITS components applicable to Goods travel, case studies

READING:

1. David Lowe, Intermodal Freight Transport, Elsevier Butterworth-Heinemann Publishers, 2005.
2. Konstadinos G. Goulias, Editor, Transportation Systems Planning: Methods and Applications. CRC Press, 2003.
3. Lester A. Hoel, Genevieve Giuliano and Michael D. Meyer, Intermodal Transportation: Moving Freight in a Global Economy, Transportation Research Forum, Eno Transportation Foundation, Washington DC, 2011
4. Moshe Ben-Akiva, Hilde Meersman and Eddy Van de Voorde, Freight Transport Modelling, Emerald Group Publishing, 2013

5. Myer Kutz, Editor, Handbook of Transportation Engineering, McGraw-Hill Publishers, 2004.
6. NCFRP Report 23, Synthesis of Freight Research in Urban Transportation Planning, TRB, Washington, 2013. http://onlinepubs.trb.org/onlinepubs/ncfrp/ncfrp_rpt_023.pdf
7. Petros A. Ioannou, Intelligent Freight Transportation, CRC Press, 2008
8. Tavasszy and De Jong, Modelling Freight Transport, 1st Edition, Elsevier Publishers, 2013.

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CE5615: LOW VOLUME ROADS
Course Type: Elective; Instruction: L-T-P-C: 3:0:0:3

Pre Requisite Courses: Nil

Course Outcomes: At the end of the course, students will be able to

CO1	Plan the rural road network.
CO2	Determine the sight distance, horizontal curvature, super elevation, grades, visibility on vertical curves, cross section elements.
CO3	Justify the geometric design standards adopted for low volume roads.
CO4	Plan surveys, and prepare survey forms.
CO5	Perform safety audit at different stages of road construction.
CO6	Design both flexible and rigid pavements for low volume roads.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2		1	2			2	1
CO2	2	3		1			1	3		
CO3	3		3	2		3			1	2
CO4		3	2		3		3	2		3
CO5	1	3		3	3	1		3	3	
CO6		2		1			3	3		1

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Low Volume Road and Network Planning:
Significance of LVRs, road classification history, definition of a low-volume road, characteristics of LVRs, rural roads vision 2025, features of PMGSY, development of LVRs in India, International scenario of LVRs, master plan and core network concepts, concepts of network planning of LVRs, System's Approach, NATPAC model, CRRI model, FBRNP model, central place theory, GIS based network planning, common terminology used in LVRs.

Geometric Design:
Topography and physical features, traffic, geometric design standards for LVRs with special reference to PMGSY, Hill road standards, Design concepts and criteria, cross sectional elements, LVRs Internationally, recommendations, cross drainage works, horizontal alignment, vertical alignment and traffic engineering requirements, international experience and various countries standards on LVRs geometric designs.

Marginal Materials:
Introduction to conventional materials, marginal and waste materials, potential source of marginal materials, subgrade soil stabilization, dealing with poor subgrades, overview of tests on aggregates and bitumen, marginal materials guidelines, framework for the appropriate use of marginal materials, key factors for consideration, Geosynthetic types and manufacture, tests, functions

Design of Low Volume Roads:
Low volume road design principles, purpose of pavement, vehicle classifications, traffic volumes, equivalent standard axles per vehicle class, design traffic classes, pavement design methods for LVRs, empirical approaches, AUSTROADS pavement design guide, AASHTO guide design, US mechanistic-empirical pavement design guide, selected pavement design methods in Indian context, flexible and rigid pavement using IRC methods and gravel road design.

Construction and Maintenance:
Case studies of waste material utilization in rural roads, low cost, techniques for rural road construction, MoRD specifications for requirements of subgrade, road base, sub-base, quality control , failures and maintenance of LVRs polices in Indian context.

READING:

1. A. Veeraragavan, S.K. Khanna and C.E.G. Justo, Highway Engineering, Nem Chand & Brothers, 2014.
2. Bruton, M. J., *Introduction to Transportation Planning*, UCL press, London, UK, 1992.
3. Ethiopian Roads Authority, Design Manual for Low Volume Roads, Parts A-G: http://www.icafrica.org/knowledge-publications/article/design-manual-for-low-volume-roads-parts-a-g-116/
4. Gordon Keller and James Sherar, Low-Volume Roads Engineering: Best Management Practices – Field Guide, USDA Forest Service/USAID, 2003. http://www4.worldbank.org/afr/ssatp/Resources/HTML/LVSR/English/Added-2007/2003-LVR-Engineering-FieldGuide-USA-by-GKeller.pdf
5. IRC SP 20: Rural road manual, Indian road congress, New Delhi, 2002.
6. MoRD, Specifications for Rural Roads, Ministry of Rural development (Fifth revision), Indian road congress, New Delhi, 2014.
7. Robert A. Douglas, Low-Volume Road Engineering: Design, Construction and Maintenance, CRC Press 2015
8. Yan H. Huang, Pavement Analysis and design, Second Edition, Prentice Hall Inc, 2004.

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CE5616: RAILWAY INFRASTRUCTURE PLANNING AND DESIGNING
Course Type: Elective; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Understand the importance of railway infrastructure planning and design.
CO2	Identify the factors governing design of railway infrastructures.
CO3	Analyze the railway track system and signal system with the available methods.
CO4	Maintain the railway track and apply remedial measures.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1						2		2		
CO2	3	3	2		2			2	2	
CO3		3		2	2	1		3		
CO4	3	3	2		3		3			3

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Planning of railway lines network

Railways operational system, historical background of Indian railways, plans and developments, policy and standards, traffic forecast and surveys, railway alignment, project appraisal and organization setup.

Component of railway track and rolling stock:

Permanent way, forces acting, rails, function of rails, rail fixtures and fastenings, sleepers and ballast, rail joints, elements of junctions and layouts, types of traction, locomotives and other rolling stock, brake systems, resistance due to friction, wave action, wind, gradient, curvature, starting, tractive effort of a locomotive, hauling power of a locomotive.

Geometric design of railway track:

Right of way and formation, field investigation, geometric design elements, safe speed on curves, speeds computation, string lining of curves, gradients, grade compensation, railway cant and cant deficiency, traction.

Track construction and maintenance

Special considerations and construction practices, track laying, inspection and maintenance, maintenance tools, maintenance of rail surface, track drainage, track circuited lengths, track tolerances, mechanized method, off-track tampers, shovel packing, ballast confinement and directed track maintenance, bridge maintenance, renewal, classification of renewal works, through sleeper renewals, mechanized relaying, track renewal trains.

Signaling and interlocking:

Objectives, classification, fixed signals, stop signals, signaling systems, mechanical signaling system, electrical signaling system, systems for controlling train movement, interlocking, modern signaling installations.

Railway accidents and safety:

Train accidents, collision and derailments and their causes, restoration of traffic, safety measures, disaster management, classification of level crossings, accidents at level crossings, remedial measures, maintenance of level crossings.

Railway Station and Yards:
Site selection, facilities, classification, platforms, building areas, types of yards, catch sidings, ship sidings, foot over bridges, subways, cranes, weigh bridge, loading gauge, end loading ramps, locomotive sheds, ash-pits, water columns, turntable, triangles, traverse, carriage washing platforms, buffer stop, scotch block, derailing switch, sand hump, fouling mark.

High Speed Railways:
Modernization of railways, effect of high speed track, vehicle performance on track, high speed ground transportation system, ballastless track, elevated railways, underground and tube railways

READING:

1. Clifford F. Bonnett, Practical Railway Engineering, 2nd Edition, Imperial College Press, London, 2005.
2. Gupta, B.L. and Amit Gupta, *Railway Engineering*, Third Edition, Standard Publishers, New Delhi, India, 2005
3. J.S. Mundrey, Railway Track Engineering, Fourth Edition, Tata McGraw-Hill Education Private Limites, New Delhi, 2010.
4. Rangwala, S.C. *Railway Engineering*, Charotar Publishing House, Anand, India, 2008.
5. S.C. Saxena and S.P. Arora, *A textbook of Railway engineering*, Sixth Edition, Dhanpat Rai Publications, 2001.
6. Satish Chandra and M. Agrawal, *Railway Engineering*, Second Edition, Oxford University Press, 2013.
7. William W. Hay, Railroad Engineering, Second Edition, John Wiley & Sons, New York, 1982.

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CE5617: SUSTAINABLE TRANSPORTATION
Course Type: Elective; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Define sustainable transportation and differentiate sustainable transportation systems from non-sustainable transportation systems
CO2	Develop a sustainable transportation system.
CO3	Consider sustainability in providing mode choices for the public.
CO4	Plan for pedestrian facilities
CO5	Plan for bicycle facilities
CO6	Suggest policies that improve the sustainability of transportation.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		1	3			1			2	
CO2		2	3			1			2	
CO3		2	3			1			2	
CO4		3	3			1			2	
CO5		2	3			1			2	
CO6		1	3			1			2	

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Problem of Sustainability in Transport:
Energy use in transport sector; Transport and climate change; Greenhouse gas emissions, urban air quality, Congestion and sustainability.

Planning for Sustainability:
Urban form, Indicator based planning, land use transportation integration, Compact City, Public Transit, TOD, NMT, First and Last Mile Connectivity.

Evaluation of Non-motorized Transportation:
Surveys, Demand Estimation and Analysis; Crash Data, Barrier Effect; Cycling Condition Evaluation Techniques; Pedestrian Condition Evaluation Techniques; Prioritizing Improvements and Selecting Preferred Options.

Planning for Pedestrians:
Types of pedestrians and Characteristics; Pedestrian facilities and planning; Pedestrian standards and improvements; Pedestrian facility Design, LOS; Pedestrian safety programs

Planning for Bicyclists:
Types of cyclists and Bikeways; Integrating cycling into roadway planning; Bicycle network planning; Accommodating cyclists on rural roads; Design of Bicycle boulevards/bike paths; Bicycle Parking/storage Facilities; Roadway maintenance for cyclists.

Sustainable Policies:
Continuum of Policies, speed and speed limit policies, national policies, sustainable travel demand management; public awareness; pricing transportation: full cost of transportation, pricing and taxation.

Sustainable Technology:
Telecommuting, Information and Communication technologies, E-commerce, Alternative Cleaner Fuels, vehicle technologies, fuel cells, Intelligent Transport Systems.

Nationally Appropriate Mitigation Actions:
Mobility Management policies, Supporting Bicycling, Creating pedestrian friendly facilities, encouraging Public Transportation

READING:

1. Black, W.R., Sustainable Transport: Problems and Solutions. Gulford Press, New York, 2010.
2. Henrik Gudmundsson, Ralph P. Hall, Greg Marsden and Josias Zietsman, Sustainable Transportation: Indicators, Frameworks and Performance Management, Springer, 2016
3. Jeffrey Tumlin, Sustainable Transportation Planning: Tools for creating Vibrant, Healthy and Resilient Communities, John Wiley & Sons, Inc, New Jersey, 2012
4. John Forester, Bicycle Transportation: A Handbook for Cycling Transportation Engineers, MIT Press, London, 1994.
5. John J. Fruin, Pedestrian Planning and Design, Elevator World, 1987 (Digitized 2011)
6. Hugh McClintock, Planning for Cycling: Principles, practice and Solutions for urban planners, CRC Press, New York, 2002
7. Preston L. Schiller, Eric C. Brunn and Jeffrey R. Kenworthy. An Introduction to Sustainable Transportation: Policy, Planning and Implementation, earthscan, London, 2010.
8. Rodney Tolley, Editor, Sustainable Transport: Planning for walking and cycling in urban environments; CRC Press, 2003.
9. Transportation Research Board, Integrating Sustainability into the Transportation Planning Process, Conference Proceedings 37, Transportation Research Board, Washington, D.C., 2005.
10. World Bank, Sustainable Transport: Priorities for Policy Reform, The World bank, Washington D.C., 1999.

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CE5618: TRAFFIC CONTROL AND MANAGEMENT
Course Type: Elective; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Understand the traffic regulations and control policies.
CO2	Design and suggest speed control measures for all types of roads.
CO3	Design traffic control systems for urban and rural roads.
CO4	Develop traffic management strategies at local level road network.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		3	2			1	1		1	
CO2		3	3			1	1		1	
CO3	3	3	3			1	1		1	
CO4	1	3	3			1	1		1	

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Traffic control and regulations:
Traffic control and its necessity, types, emerging technologies, benefits, strategies, legislation related to traffic control, highway and urban road traffic acts, traffic control warrants, traffic control aids, road signs and signals for traffic control, placement of signs.

Speed control measures:
Free speed and speed limits, road works speed limit, highway speed control, speed control in residential areas, counter measures; speed humps, speed cushions, speed tables, raised intersection, center Island, surface treatments and markings, in-roadway warning lights, community awareness and education, speed enforcement, signs for speed control, case studies.

Urban and interurban traffic control:
Control variables, mid block and intersection traffic controls studies, arterial roads and network controls, traffic at isolated intersections and control, signals and controllers, basic signal design, bicycle and pedestrian considerations, vulnerable and disable road users work zone and school zone traffic control, control systems, special controls, measure of effectiveness, public transport priorities, signal coordination, interurban highways, high speed corridors, design of rural highways and control systems, high speed expressways, access control, design example and case studies.

Traffic management and strategies
Traffic management concepts, traffic monitoring, incident detecting and advising road users, traffic system and management centers, communication and information systems, methods of information disseminations, traffic segregation, diversions and one-way street, traffic operational management, exclusive lanes, integrated traffic management, ITS strategies for advanced traffic management, design examples.

Area Traffic Control:
Local level traffic planning and management, residential neighbourhood, street lighting equipment, maintenance and installation issues land use developments and traffic system, computer applications and traffic simulation, case studies.

READING:

1. Hamada Alshaer *Demanding Traffic Control and Management in Next Generation Networks,* Lap Lambert academic publishing, 2010
2. Institute of Transportation Engineers, Anurag Pande and Brian Wolshon, Traffic Engineering Handbook, Seventh Edition, John Wiley & Sons, New Jersey, 2016.
3. John E. Tyworth and Joseph L. Cavinato, Traffic Management: Planning, Operations and Control, Addison-Wesley Pub. Co., 1987
4. Laurence Olivo, Traffic Management, Emond Montgomery Publications, 2007
5. Michael Welzl, *Network Congestion Control: Managing Internet Traffic* Publisher: John Wiley & Sons, 2005
6. Myer Kutz, Editor, Handbook of Transportation Engineering Volume I & II, 2nd Edition, McGraw-Hill Professional, 2011
7. Slobodan Guberinic, Gordana Senborn and Bratislav Lazic, Optimal Traffic Control Urban Intersections, CRC Press, London, 2011

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CE5619: TRANSPORT POLICY AND FINANCING
Course Type: Elective; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Understand the issues related to transportation policy and the role of engineers and planners in transportation policy making.
CO2	Participate in developing the transportation policy for the nation.
CO3	Understand the objectives of the national transport development policy and the approach the nation should take with regards to different transportation sectors to achieve them.
CO4	Understand the historical and current methods of transportation funding in India.
CO5	Understand the role of private parties in transportation financing.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		2	2	1	2		2		1	
CO2			2	1	1		1			
CO3		2	1	1	1					
CO4		1	1	1	1					
CO5		1	1		1		1			

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Issues in transport policy:
Historical background on transportation policy and financing, Role of transportation engineers and planners in transportation policy making, Issues in transport policy, transportation policy formulation process - Policy making process, Transportation taxes, Equity and fairness in transportation, Policies affecting travel behavior, Environmental issues and sustainability.

National transport development policy
Background: Formation of the NTDP committee, its objective and functions; Approach: Growth projections, specific transport systems, institutional framework for formulation of transport policy, planning and coordination; Railways, roads, ports and airways, Transportation of key commodities, promotion of integrated transport and logistics systems, Human resource development for the transportation sector, Urban transport; safety policy; transportation in the North East.

National Urban Transport Policy:
Equitable allocation of road space, Encourage greater use of public transport and non-motorized modes of transport, Integrated land use and transport planning, Five Year Plans - Transportation Policy: Economically rational inter-modal mix, Consortium approach for financing Urban Transport projects, Institutional arrangements for planning and developing urban transport, Unified Metropolitan Transport Authority in metropolitan cities, Innovations in transportation policy.

Five year plans - transportation policy
About five year plans, Transportation policy changes in the five year plans.

Various acts related to Transport:
Motor vehicle act, Vehicle registration system, Laws Governing Access Control to National Highways, Laws Governing Inter-state movement of goods and vehicles

Investment policies and pricing:
Traditional cost-benefit analysis, increased competition created by improved transport, Reduction of transport barriers.

Role of Private Participation:
Need for private participation, advantages and disadvantages, Public-private partnership, BOT, BOO etc.; Contracts for services, not procurement of assets, Payments related to service delivery, Whole life approach to design, build and operation Clear legal and institutional framework, Transparent and competitive procurement, implementation, risks for government and private parties.

Transportation Financing:
Pricing and subsidy issues; Economic and financial dimensions of urban transportation systems, User fees, Toll financing and congestion pricing, Fare and subsidy policies, Social costs of transportation systems

READING:

1. Commission of the European Communities, Institution of Civil Engineers (Great Britain), Highway Investment in Developing Countries, Thomas Telford Ltd., 1983. (Digitised in 2011)
2. Dai Nakagawa and Ryoji Matsunaka, Transport Policy and Funding, Elsevier, Oxford, UK, 2006
3. David Banister and Joseph Berechman, Transport Investment and Economic Development, UCL Press, London, 2000
4. Kenneth A. Small and Erik T. Verhoef, Urban Transportation Economics, 2nd Edition, Routledge, London, 2007.
5. National Transport Development Policy Documents, Government of India, New Delhi, 2012.
6. National Urban Transport Policy, Ministry of Urban Development, Government of India, New Delhi, 2006.
7. Peter Stopher and John Stanley, Introduction to Transport Policy: A Public Policy View, Edward Elgar Publishing Limited, UK, 2014.
8. Various National Acts on Transport.

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CE5620: TRANSPORTATION DATA ANALYSIS
Course Type: Elective; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Understand and Analyse probability distributions.
CO2	Carry out multivariate data analysis and identify correlations.
CO3	Develop Time Series Models.
CO4	Estimate Parameters using appropriate techniques.
CO5	Test hypothesis using goodness of fit measures.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	1		1			1			
CO2	3	1		1			1			
CO3	3	1		1			1			
CO4	3	1		1			1			
CO5	3	1		1			1			
CO6										

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Data description and presentation:
Type of data, center of data, quartiles, five number summary, spread of data, coefficient of variation and standard deviation, measure of dispersion, shape of data, coefficients of skewness and kurtosis, descriptive data statistics, presentation of categorical, quantitative and qualitative variable, data frequency and histogram, exercises with real data.

Sampling techniques:
Sample surveys, census, sampling bias, random sampling, stratified sampling, sequential sampling, cluster sampling, systematic sampling, sampling on successive occasions, non-sampling errors, applications in transportation engineering.

Parameter estimation and Curve fitting:
Least square, generalised least squares, method of moments, maximum-likelihood, algebraic and geometric curve fit, linear and non-linear curve fitting (polynomial, exponential, logarithmic, power etc.), over fit and under fit, exercises with real data.

Regression and Correlation:
Simple linear regression, residuals and variances, multiple linear regression, two stage regression, forward, backward and step-wise regression, residual analysis, correlation analysis, type of correlations, coefficient of correlation, Karl-Pearson's coefficient, multivariate data analysis, factor analysis, applications in transportation engineering.

Probability laws and distributions:
Basic probability theory, concept and rules, Bayes' theorem, type of statistical distribution and characteristic, probabilistic distributions- Binomial, Poisson, Normal, Lognormal, Weibull, Gamma, Beta, Erlang, Student's t and F distribution, Geometric and Hyper geometric distribution, applications in transportation engineering.

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

Time series and Forecasting:
Time series concept and components, utility, time series models, measurement of time series, graphical method, method of semi-average, moving average, least square, linear, parabolic and logarithmic trends, growth curves, ratio-to-trend and link relative method for seasonal variation, exercises with transportation data.

Reading:

1. Bovas A., Nair N. U., *Quality improvement through statistical method,* Springer Science *&* Business Media, 1998.
2. F.D. Hobbs, Traffic planning and engineering, Second Edition, Pergamon Press, New York, 1979.
3. Haberman, R., *Mathematical Models*, Prentice Hall, 1997.
4. Joseph F. Hair, William C. Black, Barry J. Babin and R. Anderson E.*, Multivariate data analysis*, 7th Edition, Prentice Hall, 2009.
5. Leland T. Blank, *Statistical procedures for engineering, management, and science*. McGraw Hill, Book, London, 1980
6. P.N. Arora, S. Arora, Arora A., *Elements of statistical method*, S. Chand & Company LTD., New Delhi, 2009.
7. Reinhold D., *Advances in data analysis,* Proceedings of the 30th Annual Conference*,* Springer Science & Business Media, 24-Mar-2007.
8. Robert V. Hogg, and E. Tanis A., *Probability and statistical inference*, 6th Edition, Prentice Hall, 2000
9. Simon P. Washington, Matthew G. Karlaftis, Fred, Mannering L., *Statistical and econometric methods for transportation data analysis*, CRC Press, Second Edition, 2010.
10. Washinton SP, Karlafits MG, Mannering F.L., *Statistical and econometric method for transportation data analysis*, 2nd addition, CRC Press, 2011.

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CE5621: TRANSPORTATION SYSTEM MANAGEMENT
Course Type: Elective; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Understand TSM, the need for TSM and the objectives of TSM.
CO2	Understand the types of TSM strategies.
CO3	Apply a strategy based on a TSM goal or objective.
CO4	Recommend methods to manage a transit system to improve its management efficiency.
CO5	Understand transportation demand management (TDM), various TDM strategies and their applicability.
CO6	Recommend a detailed transportation demand management strategy for a transportation system based on a goal or objective.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		1	3				2		1	
CO2		1	3				2		1	
CO3		1	3				2		1	
CO4		1	3				2		1	
CO5		1	3				2		1	
CO6		1	3				2		1	

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Transportation System Management:
Objectives; Need for TSM Long – Range vs. TSM Planning; TSM Actions: Traffic Management Techniques for Improving Vehicular Flows, Preferential Treatment for High occupancy Modes; Promoting Non – Auto and High Occupancy vehicles; Transit and Intermediate Public Transport service Improvements, Demand Management Techniques for Reduced Traffic Demand, Staggered working Hours, Vehicular Restrictions, Intersection Management Techniques – Signal Progression – Optimisation

Transit System Management:
Multimodal traffic management, Reducing transportation needs, Reducing dependence on car, Improving traffic flow, Improving road safety, Route Planning and Scheduling.

Transportation Demand Management:
Usage of Personal Vehicle, Non-motorized Transport and Public Transit, Policies to Control Vehicle Growth Rate, Alternative work schedules, Congestion pricing, Employer incentives and disincentives, Land-use reorientation, ICT applications.

Traffic Administration:
Legislative Authority; Functional Responsibilities; Organisation – UMTA – State Highway Department; Traffic Records; Research Bodies; Citizen Participation, Asset Management

READING:

1. Institute of Transportation Engineers. Anurag Pande and Brian Wolshon, Traffic Engineering Hand Book, Seventh Edition, Prentice Hall, 2016
2. ITE, Transportation System Management and Operations: Action Kit – Immediate Solutions for Transportation Operational Issues, FHA, ITE, 2005

3. Khisty CJ and BK Lall, Transportation Engineering: An Introduction Prentice Hall International, Inc., 2012
4. Stephen Ison and Tom Rye (Editors), The Implementation and Effectivenee of Transport Demand Management Measures: An International Perspective, Ashgate Publishing Company, 2008
5. Sunil Sharma, Travel Demand Management, Rajat Publications, 2007
6. Transportation System Management, State of the Art, UMTA, USDOT, 1978

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CE5622: WATERWAY INFRASTRUCTURE PLANNING AND DESIGN
Course Type: Elective; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Plan and design harbour facilities.
CO2	Estimate Traffic demand for harbour planning.
CO3	Discriminate harbour works, berthing structures and transit sheds.
CO4	Understand repair facilities, port facilities and cargo handling facilities required.
CO5	Design coastal protection facilities.
CO6	Understand navigational aids and inland navigation for safe operations.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2	3	1			1				
CO2	2	2								
CO3		1								
CO4		1								
CO5	2	3				1		2		
CO6		1								

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Harbour Planning:
Types of water transportation, water transportation in India, requirements of ports and harbours, classification of harbours, selection of site and planning of harbours, location of harbour, traffic estimation, master plan, ship characteristics, harbour design, turning basin, harbour entrances, type of docks, its location and number, Site investigations – hydrographic survey, topographic survey, soil investigations, current observations, tidal observations.

Harbour Works:
Design and construction of breakwaters, berthing structures - jetties, fenders, piers, wharves, dolphins, trestle, moles, navigational aids, requirements of signals, fixed navigation structures, necessity of navigational aids, light houses, beacon lights, floating navigational aids, light ships, buoys, radar.

Docks and Repair Facilities:
Harbor docks, use of wet docks, design of wet docks, repair docks, lift docks, dry docks, keel and bilge blocking, construction of dry docks, gates for dry docks, pumping plant, floating docks, slipways, locks, size of lock, lock gates, types of gates.

Port facilities:
Port development, port planning, port building facilities, transit sheds, warehouses, cargo handling facilities, container handling terminal facilities, shipping terminals, inland port facilities.

Dredging and Coastal Protection:
Classification, types of dredgers, choice of dredger, uses of dredged materials, coastal erosion and protection, sea wall, revetment, bulkhead, coastal zone and beach profile.

Inland Navigation:
Inland waterways, Inland water transportation in India, classification of waterways, economics of inland waterways transportation, national waterways.

READING:

1) Brysson Cunningham, The Dock and Harbour Engineer's Reference Book: Being a Compilation of Notes on Vrious Matters Connected with Maritime Engineering and Ports and Harbours, BiblioLife, 2014
2) Carl A Thoresen, Port Designer's Handbook: Recommendations and Guidelines, Thomas Telford, 2006
3) Gregory P. Tsinker, Handbook of Port and Harbor Engineering: Geotechnical and Structural Aspects, 2014
4) Hasmukh P. Oza and Gautam H. Oza, Dock and Harbour Engineering, Sixth Edition, Charotar Publishing House Pvt. Ltd., 2011
5) S.B. Junnarkar and H.J. Shah, Dock and Harbour Engineering, Charotar Publishing House Pvt. Limited
6) Seetharaman, S. *Dock and Harbour Engineering*, Umesh Publications, New Delhi, India, 1999.
7) Srinivasan, R. *Harbour, Dock and Tunnel Engineering*, Charotar Publishing House Pvt. Ltd., Anand, India, 2009.

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M.Tech (Transportation Engineering) II Semester

CE5651: ADVANCED TRAVEL DEMAND MODELLING
Course Type: Elective; Instruction: L-T-P-C: 4-0-0-4

Pre Requisite Courses:
1. CE5601: Urban Transportation Planning

Course Outcomes: *At the end of the course, students will be able to*

CO1	Assess Qualitative Variables.
CO2	Develop discrete choice models.
CO3	Develop travel demand models using Stated Preference data.
CO4	Estimate Travel Demand using activity based analysis.
CO5	Test model aggregation and transferability.
CO6	Develop Travel Demand Models for small cities using Quick response techniques.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	1	1		1				
CO2	3	3	2	2		2				
CO3	3	3	2	2		2				
CO4	3	3	2	2		2				
CO5	2	2	1	1		1				
CO6	1	2	1							

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Discrete choice analysis:
Utility Concept; Mode choice; Logit Models; Dogit Model; Nested Logit Model; Probit Model; Route Choice Modelling; Combined Travel Demand Modelling; Model Parameter Estimation – Maximum Likelihood and Maximum Entropy Estimates.

Stated preference methods:
Stated preference vs. Revealed Preferences; Design Issues; Survey Methods, Conjoint Analysis; Functional Measurement; Trade off Analysis, Transfer Price Method

Activity Based Travel Demand Models:
Activity patterns; Activity scheduling; Activity Time Allocation studies; Activity Episode Analysis; Travel Duration Analysis

Qualitaive variables:
Role of Soft variables in Travel Demand Forecasting; Attitudes; Psychometric scaling Techniques – One-dimensional Scaling – Multidimensional Scaling; Basic Rating Scales: Comparative Rating Scales, Non – Comparative Rating scale, Itemised rating scale, graphic rating scale; Specific Attitude scales; Successive Categories; Principal Components Factor Analysis; Attitudinal Models.

Model aggregation and model transferability:
Aggregation bias and forecasting; Aggregation Methods; Temporal Stability and geographical stability of Models; Transfer Model Updating Procedures – Transferring with Aggregate and Disaggregate sample data; Transferability Measures.

Simplified transport demand models:
Sketch planning Methods; Incremental Demand Models; Model estimation from traffic Counts; IVF Models, Marginal and Corridor Models; Gaming Simulation, Quick Response Techniques.

Introduction to advanced modeling techniques:
GO Models; Entropy Models; Equilibrium Assignment Techniques, Multipath Assignment – Dial's Algorithm, Knowledge Based Expert System; Neuro – Fuzzy Application; ANN Techniques; Genetic Algorithms; Object Oriented Programming; Decision Support Systems; Goal Programming.

READING:

1. Akiva, B., *Discrete Choice Analysis: Theory and Application to Travel Demand*, MIT Press, 1985.
2. Alan Geoffrey Wilson. Optimisation in Location and Transport Analysis, John Wiley & Sons, 1981 (Digitized: 31 March 2011).
3. Harry Timmermans, *Progress in Activity Based Analysis*, Elsevier Science, 2005.
4. Joe Castiglione, Mark Bradley and John Gliebe, Activity-Based Travel Demand Models: A Primer, TRB, Washington, D.C., 2015
5. Jordon J. Louviere, David A. Hensher, and Joffre D. Swait, Stated Choice Methods: Analysis and Applications, Cambridge University Press, 2003
6. Juan de Dios Ortuzar, and Luis G. Willumsen, L. G., *Modelling Transport,* Fourth Edition, Wiley Publishers, 2011.
7. Laurie A. Garrow, Discrete Choice Modelling and Air Travel Demand: Theory and Applications, Routledge, 2010
8. Oppenheim, N., *Urban Travel Demand Modelling: From Individual Choices to general Equilibrium*, John Wiley and Sons, Inc., 1995 (Digitized 29 June 2011).
9. Transportation Research Board, Activity and Time Use Analysis 2007, TRB Record, TRB, 2007.

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CE5652: TRAFFIC SYSTEM DESIGN
Course Type: Core; Instruction: L-T-P-C: 4-0-0-4

Pre Requisite Courses:
1. CE5602: Traffic Analysis

Course Outcomes: *At the end of the course, students will be able to*

CO1	Design the geometric elements for better traffic system.
CO2	Analyze and design uncontrolled and signalized intersection with collected data.
CO3	Design and improve the bicyclists and pedestrians traffic flow facilities.
CO4	Analyze and design appropriate parking layouts and facilities.
CO5	Examine and design better street lighting systems.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2	3	2	2				2		2
CO2	3	3	3	3			2	3	3	2
CO3	2	3	3	3			2	3	3	2
CO4	3	3	3	3			2	3	3	2
CO5	3	3	3	3			2	3	3	2

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Geometric design of traffic flow systems:
Elements of geometric design, cross sectional elements, sight distance considerations, factor affecting geometric design, highway alignment and topography, design of horizontal alignment, tangents and curves, layouts and radius, design of vertical alignment, tangent grades, vertical curvature, design controls and criteria, mobility and accessibility, landscaping, design of freeway and multilane highways, expressways design requirements, weaving segments and configurations, auxiliary lanes and its elements, speed change lanes, and design practice.

Design of at grade intersections:
At grade intersections types and their suitability, factors affecting design, data requirement, parameters selection, intersection controls, estimation of conflict points, uncontrolled intercession analysis, capacity of rotary, roundabouts and design methodologies, Design of signalized intersection, warrants for signalization, saturation flow rate and capacity, estimation of amber time, design of all aspects of signal timings, LOS studies, estimation of queue length and control delay, signal coordination, channelization and its objectives, channelizing devices, design considerations, typical channelizing examples.

Design of traffic Interchanges and its elements:
Necessities of interchanges, classification and types of common interchanges, layouts of interchange, interchange warrants, interchange design elements, spacing and design speed, design of ramps, ramp configurations, weaving at interchange, design examples.

Design of traffic system for bicycle and pedestrians:
Bicycle flow characteristics, performance measures, LOS criteria and capacity, interrupted and uninterrupted bicycle paths, design of bikeways, shared off-street and on-street paths, urban street bicycle path, control delay and LOS, pedestrian flow behavior, factor affecting behavior, fundamental traffic flow relations, pedestrians space requirement, performance measures, pedestrian demand analysis, design of pedestrians facility at uncontrolled and signalized junctions, side walk and cross walk design, street corner analysis, pedestrian signals, and design examples.

Design of parking facilities:
Parking and influencing factors, type of parking system, parking angles and aisle width, on-street parking design, design parameters, parking surveys and demand estimation, various parking layouts and vehicle circulation, design of off street parking facilities, types and layouts, design examples.

Street lighting:
Definitions and background, pavement luminance and its measurement, illumination level, Veiling Luminance, longitudinal uniformity, utilization factor, depreciation factor, maintenance factor, traffic criteria and warranting conditions, and design practice.

READING:

1. C. Jotin Khisty and B. Kent Lall, Transportation Engineering: An Introduction, Third Edition, Prentice Hall; 2002.
2. Coleman A. O 'Flaherty, Transport Planning and Traffic Engineering, Butterworth-heinemann, 2009.
3. Fred L. Mannering, Scott S. Washburn, Kilareski Walter P., Principles Of Highway Engineering And Traffic Analysis, Wiley India Pvt Ltd., 4th Edition, 2011.
4. Institute of Transportation Engineers, Anurag Pande and Brian Wolshon, Traffic Engineering Handbook, Seventh Edition, John Wiley & Sons, New Jersey, 2016.
5. L.R. Kadiyali, Traffic Engineering and Transportation Planning, Khanna Publishers, 2011.
6. Louis J. Pignataro and Edmund J. Cantilli, Traffic Engineering: Theory and Practice; Prentice hall, Inc.1973 (Digitised in 2007)
7. Mike Slinn, Paul Matthews, Peter Guest, Traffic Engineering Design: Principles and Practice, Butterworth-heinemann, 2nd Edition, 2005.
8. Nicholas J. Garber, and Lester A. Hoel, Principles of Traffic and Highway Engineering, Cengage Learning India, 2nd Edition, 2010.
9. Richard J. Salter and N.B Hounsell, Highway Traffic Analysis and Design, Third Edition, Macmillan, 1996.
10. Roger P. Roess, Elena S. Prassas and William R. McShane, Traffic Engineering, Prentice Hall, 4th Edition, 2010.

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CE5653: PAVEMENT CONSTRUCTION AND EVALUATION
Course Type: Core; Instruction: L-T-P-C: 4-0-0-4

Pre Requisite Courses:

1. CE5603: Pavement Analysis and Design

Course Outcomes: *At the end of the course, students will be able to*

CO1	Select appropriate earth moving and compaction equipment depending upon the requirement.
CO2	Prepare quality assurance and quality control plans in an attempt to construct better performing pavements.
CO3	Evaluate the pavements based on the functional and structural characteristics.
CO4	Evaluate the safety aspects of the pavements specifically in terms of friction and other related distresses.
CO5	Select maintenance technique depending upon the intensity of the distresses.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		3								
CO2		3					1	3	1	
CO3	1		2	1						
CO4	1		2	1						
CO5		1	2							

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Highway Construction Equipment:
Applications and safety aspects of earth moving equipments, compaction equipments, road making equipments, concreting equipments and paving equipments.

Pavement Construction:
Construction and preparation of subgrade soil, construction of sub-base layer, construction of base layer, construction of bituminous surface layers, construction of cement concrete surface layer and MoRT&H specifications.

Functional Evaluation of Pavements:
Introduction, factors affecting pavement deterioration, functional condition evaluation techniques, roughness measurements, Identification of uniform sections, serviceability concepts, visual and ride rating techniques

Structural Evaluation of pavements:
Structural condition evaluation techniques, NDT procedures, rebound deflection, deflection bowl measurement and analysis, IRC overlay design method, structural evaluation using falling weight deflectometer, back calculation of layer moduli, ground penetrating radar for pavement evaluation, evaluation of pavement safety: skid resistance and hydroplaning.

Pavement Maintenance:
Routine maintenance, periodic maintenance, special repairs, responsive maintenance programme, rehabilitation and reconstruction, treatment strategies and selection

READING:

1) **David Croney and Paul Croney,** *The Design and Performance of Road Pavements*, Third Edition, McGraw-Hill Professional, 1997.

2) **Haas, R., W.R. Hudson** and **J.P. Zaniewski.** *Modern Pavement Management*, Krieger Publishing Company, Malabar, Florida, USA, 1994.
3) **Mallick, R.B.** and **T. El-Korchi** *Pavement Engineering – Principles and Practice*, CRC Press, Taylor and Francis Group, Florida, USA, 2009.
4) **Ministry of Road Transport and Highways.** *Specifications for Road and Bridge Works*, Fifth Edition, Indian Roads Congress, New Delhi, India, 2013.
5) **Nai C. Yang,** *Design of Functional Pavements*, McGraw-Hill Book Company, New York, USA, 1972 (Digitised in 2007)
6) **Papagiannakis, A.T.** and **E.A. Masad** *Pavement Design and Materials*, John Wiley and Sons, New Jersey, USA, 2008.
7) **Rajib B. Mallick and Tahar El-Korchi,** Pavement Engineering: Principles and Practice, Second Edition, CRC Press, London, 2013
8) **Shahin, M.Y.** *Pavement Management for Airports, Roads, and Parking Lots*, Third Edition, Kluwer Academic Publisher, Massachusetts, USA, 2005.
9) **Yang H. Huang,** *Pavement Analysis and Design*, Second Edition, Pearson Prentice Hall, New Jersey, USA, 2004.
10) **Yoder, E.J.** and **M.W. Witczak** *Principles of Pavement Design*, Second Edition, John Wiley and Sons, New York, USA, 1991.

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CE5654: PAVEMENT MATERIALS AND EVALUATION LABORATORY
Course Type: Core; Instruction: L-T-P-C: 0-0-3-2

Pre Requisite Courses:

1. CE5603: Pavement Analysis and Design

Course Outcomes: *At the end of the course, students will be able to*

CO1	Characterize the pavement materials including soil, aggregate, bitumen, and bituminous mixes in the laboratory.
CO2	Perform quality control tests on pavements and pavement materials.
CO3	Measure the functional response characteristics of in-service pavements.
CO4	Measure the structural response characteristics of in-service pavements.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	1	1	2	3	3
CO2	3	3	2	3	3	1	1	2	3	3
CO3	3	3	2	3	3	1	1	2	3	3
CO4	3	3	2	3	3	1	1	2	3	3

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

1 **Tests on Soils:** liquid limit, plastic limit, soil classification (dry and wet), maximum dry density and moisture content.
2 **Tests on Soils:** CBR.
3 **Tests on Aggregate:** aggregate gradation, shape tests, specific gravity, water absorption.
4 **Tests on Aggregate:** Los Angeles abrasion value, aggregate impact value, soundness test.
5 **Tests on Bitumen:** penetration, absolute and kinematic viscosity, flash and fire point, ductility and elastic recovery, softening point, specific gravity.
6 **Tests on Bitumen:** measuring apparent viscosity of bitumen using SC-4-27 spindle in a rotational viscometer from 60 to 150 °C in increments of 10 °C at different shear rates, short-term aging of bitumen.
7 **Field Tests:** field density using sand replacement method, rapid moisture meter.
8 **Tests on Bituminous Mixes:** stripping value of aggregate, determination of Gmm of given bituminous mixtures using CoreLok system, Marshall mix design.
9 **Tests on Bituminous Mixes:** bitumen content and gradation using centrifuge extractor and NCAT ignition oven, determination of tensile strength ratio for a given bitumen mix.
10 **Tests on Bituminous Mixes:** roller compaction and permanent deformation using wheel tracking equipment.
11 **Field Evaluation:** skid resistance using British pendulum, texture depth using sand patch test, stiffness of unbound pavement layers using GeoGauge.
12 **Field Evaluation:** pavement condition rating, unevenness using MERLIN.
13 **Field Evaluation:** Dynamic Cone Penetrometer, Clegg Impact Test, determination of modulus and rebound deflection using Portable Falling Weight Deflectometer.
14 **Field Evaluation:** overlay design using Benkelman beam.

READING:

1. **Khanna, S.K., Justo, C.E.G.** and **A. Veeraragavan** *Highway Materials and Pavement Testing*, 5th Edition, Nem Chand and Bros, Roorkee, India, 2009.
2. **Yang H. Huang,** *Pavement Analysis and Design*, Second Edition, Pearson Prentice Hall, New Jersey, USA, 2004
3. **Relevant IS, IRC, ASTM Codes.**

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CE5655: TRANSPORTATION ENGINEERING SOFTWARE LABORATORY
Course Type: Core; Instruction: L-T-P-C: 0-0-3-2

Pre Requisite Courses:

1. CE5601: Urban Transportation Planning
2. CE5602: Traffic Analysis
3. CE5603: Pavement Analysis and Design
4. CE5606: Computational Laboratory

Course Outcomes: *At the end of the course, students will be able to*

CO1	Estimate Travel Demand using transportation planning packages like VISUM.
CO2	Design isolated and coordinated traffic signals using SIDRA.
CO3	Design Flexible and Rigid Pavements using Ken layer and Ken slab software.
CO4	Simulate traffic at mid block as well as at Intersections using VISSIM.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3		2		2			1	
CO2	3	3		2		2			1	
CO3	3	3		2		2			1	
CO4	3	3		2		2			1	

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Exercises on Usages of the Packages and Mini-Project:

TRANSPORTATION PLANNING PACKAGES:

Trip Generation - Multiple Linear Regression Analysis.
Trip Distribution - Growth Factor Methods, Gravity Model.
Mode Choice - Logit Model.
Trip Assignment - All or Nothing Technique.
VISUM
CUBE
Land use Transportation Planning

TRAFFIC ENGINEERING PACKAGES:

MXRoad
VISSIM
SIDRA
SUMO
VISWALK
VISTRO
VISUM Safety
VISWALK

PAVEMENT EVALUATION & ECONOMIC ANALYSIS PACKAGES:

Ken-layer & Ken-slab
HDM – IV

READING:

1. User Manuals of various packages.

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CE5691: SEMINAR – II
Course Type: Core; Instruction: L-T-P-C: 0-0-2-1

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Identify and chose appropriate topic of relevance.
CO2	Assimilate literature on technical articles of specified topic and develop comprehension.
CO3	Prepare a technical report.
CO4	Design and develop presentation on a given technical topic.
CO5	Deliver technical presentation on a specified topic.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		1	1	1		2				1
CO2		2	2	2		2				1
CO3		2				2				1
CO4		2			1	2				1
CO5		1	1		1					

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

There is no specific syllabus for this course. However, student can choose any topic, of his choice, pertaining to Transportation Engineering. Topic should be a relevant and currently researched one. Students are advised to refer articles published in current journals in the area of Transportation Engineering for choosing their seminar topics. Student should review minimum of 5 to 6 research papers relevant to the topic chosen, in addition to standard textbooks, handbooks, etc. Students are required to prepare a seminar report, in the standard format and give presentation to the Seminar Assessment Committee (SAC) in the presence of their classmates. It is mandatory for all the students to attend the presentations of their classmates.

READING:

1. Guidelines for the Preparation and Delivery of a Seminar Presentation: http://www2.cs.uregina.ca/~hilder/cs499-900/Presentation%20Guidelines.pdf
2. Guidelines on Seminar Presentation: http://foodsci.rutgers.edu/gsa/SeminarGaudelines.pdf
3. Instructor Resources: Seminar Proposal Guidelines, SAE International; http://www.sae.org/training/seminars/instructorzone/proposalguidelines.pdf
4. Research Articles / Reports available on Internet.
5. Transportation Engineering Journals.
6. Transportation Engineering Textbooks and Handbooks.

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CE5661: AIRPORT INFRASTRUCTURE PLANNING AND DESIGN
Course Type: Elective; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses: NIL

Course Outcomes: *At the end of the course, students will be able to*

CO1	Analyze the effects of atmospheric variables on aircraft performance.
CO2	Fix the orientation of the runways.
CO3	Design the geometrics of the airport infrastructure.
CO4	Prepare structural designs of runway, taxiway, and apron-gate area.
CO5	Prepare a master plan for an airport.
CO6	Prepare a plan of the airport terminal area.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	1	2	2		3	1				2
CO2	2	3	2		3	1				2
CO3	2	3	2		3	1				2
CO4		3	2		3	1				2
CO5		3	2		3	1				2
CO6		3	2		3	1				2

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Airport Planning and Forecasting:

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

Aviation organizations and functions: Federal Aviation Administration, International Civil Aviation Organization, Directorate General of Civil Aviation, Airports Authority of India.

Airport planning studies: airport system plan, airport site selection, airport master plan, airport project plan; continuous planning process.

Forecasting methods: time series method, market share method, econometric modelling.

Forecasting requirements and applications.

Aircraft Characteristics:

Landing gear configurations, aircraft weight, engine types.

Atmospheric conditions affecting aircraft performance: air pressure, temperature, wind speed and direction.

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

Air Traffic Management:

Air traffic separation rules: vertical separation, flight altitudes, longitudinal separation, and lateral separation.

Navigational aids: ground based systems, satellite based systems.

Geometric Design of the Airfield:

Airport classification: utility airports, transport airports.

Runways: runway configurations, runway orientation, wind rose, estimating runway length, sight distance and longitudinal profile, transverse gradient, airfield separation requirements, obstacle clearance requirements.

Taxiways and taxi lanes: widths and slopes, taxiway and taxi lane separation requirements, sight distance and longitudinal profile, exit taxiway geometry, location of exit taxiways, design of taxiway curves and intersections, end-around taxiways.

Aprons: holding aprons, terminal aprons and ramps, terminal apron surface gradients.

Control tower visibility requirements.

Structural Design of Airport Pavements:
Soil investigation and evaluation: CBR, plate bearing test, Young's modulus, effect of frost on soil strength, subgrade stabilization.
FAA pavement design methods: equivalent aircraft method, cumulative damage failure method.
Design of flexible pavements: CBR method, layered elastic design.
Design of rigid pavements: Westergaard's analysis, finite element theory, joints and joint spacing, continuously reinforced concrete pavements.
Design of pavement overlays.

Airport Lighting, Marking, and Signage:
Requirements of visual aids, approach lighting system configurations, visual approach slope aids, threshold lighting.
Runway lighting, taxiway lighting.
Runway and taxiway marking, airfield signage.

Planning and Design of the Terminal Area:
Passenger terminal system and its components.
Design considerations: terminal demand parameters, facility classification, level of service criteria.
Terminal planning process: overall space requirements, concept development, horizontal distribution concepts, vertical distribution concepts.
Apron gate system: number of gates, ramp charts, gate size, aircraft parking type, apron layout, apron circulation, passenger conveyance to aircraft, apron utility requirements.

READING:

1) **Ashford, N. J., Mumayiz, S. A.,** and **Wright, P. H.** *Airport Engineering: Planning, Design and Development of 21st Century Airports*, Fourth Edition, John Wiley & Sons, New Jersey, USA, 2011.
2) **Horonjeff, R., McKelvey, F. X., Sproule, W. J.,** and **Young, S. B.** *Planning and Design of Airports*, Fifth Edition, McGraw-Hill, New York, USA, 2010.
3) **Kazda, A.,** and **Caves, R. E.** *Airport Design and Operation*, Second Edition, Elsevier, Oxford, U.K., 2007.
4) **Khanna, S. K., Arora, M. G.,** and **Jain, S. S.** *Airport planning and Design*, Sixth Edition, Nem Chand and Bros, Roorkee, India, 2012.
5) **Kumar, V.,** and **Chandra, S.** *Air Transportation Planning and Design*, Galgotia Publications Pvt. Ltd., New Delhi, India, 1999.
6) **Neufville, R. D.,** and **Odoni, A.** *Airport Systems: Planning, Design, and Management*, McGraw-Hill, New York, USA, 2003.
7) **Young, S. B.,** and **Wells, A. T.** *Airport Planning and Management*, Sixth Edition, McGraw-Hill, New York, USA, 2011.

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CE5662: GIS FOR TRANSPORTATION
Course Type: Elective; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Develop GIS-T Data Models.
CO2	Represent Transportation Data in GIS Environment.
CO3	Analyse Transport Networks.
CO4	Analyse and model spatial and transportation facilities in GIS.
CO5	Integrate ITS with GIS.
CO6	Map transportation related environmental pollutants, accidents in GIS platform.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2		1						
CO2	3	3		1						
CO3	2	3		1		1				
CO4	2	3		1		1				
CO5		2	1	1	2	1		1		
CO6		2	2	1	2	1		1		

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

GIS – T DATA MODELS:
Data Domains and Data Modelling in GIS – T; Data Modelling Techniques; Data Modelling and Design Issues; Graph Theory and Network Analysis; Network representation of a Transportation System; Linear referencing methods and systems; Transportation Data Models for ITS and related Applications.

TRANSPORTATION DATA SOURCES AND INTEGRATION:
Basic Mapping Concepts; Transportation Data Capture and Data Products; Transportation Data Integration; Spatial Data Quality; Spatial and Network aggregation.

SHORTEST PATHS AND ROUTING:
Fundamental Network Properties; Fundamental Properties of Algorithms; Shortest Path Algorithms; Routing Vehicles with in Networks.

NETWORK FLOWS AND FACILITY LOCATION:
Flow through Uncongested Networks; Flow through Congested Network; Facility location within Networks; Spatial Aggregation in Network Routing and location problems.

GIS BASED SPATIAL ANANLYSIS AND MODELING:
GIS and spatial Analysis; Urban sprawl; GIS Analytical functions; Coupling Transportation Analysis and Modelling with GIS; Customising GIS; Supporting Advanced Transportation Analysis in GIS.

TRANSPORTATION PLANNING:
Transportation Analysis Zone Design; Travel demand Analysis; Land use – Transportation Modelling; Route Planning; Decision support for Transportation Planning.

INTELLIGENT TRANSPORTATION SYSTEMS:
ITS Applications; ITS Architectures and Geographic Information; Integrating GIS and ITS.

TRANSPORTATION, ENVIORNMENT AND HAZARDS:
Mapping sensitive Environmental features; GIS and Transportation related Air Quality; Accidents and Safety Analysis; Transportation of hazardous Materials.

READING:

1. Alan Paul Vonderohe, Alan Travis, and Robert Smith. Implementation of Geographic Information Systems (GIS) in State DOTs: An NCHRP Digest of the Essential Findings from the Interim Report on NCHRP Project 20-27 'Adaptation of Geographic Information Systems for Transportation', *Issue 180 of Research results digest*, TRB, 1991.
2. Chor Pang Lo, and Albert K. W. Yeung, *Concepts and Techniques of Geographic Information Systems*, Prentice Hall India Pvt. Ltd, New Delhi, 2011
3. Harvey J. Miller and Shih-Lung Shaw SL, Geographic Information Systems for Transportation: Principles and Applications, Oxford University Press, 2001
4. Henk J. Scholten and John Stillwell, Geographical Information Systems for Urban and Regional Planning, Springer, 2010.
5. NCHRP Report 359. Adaptation of Geographic Information Systems for Transportation, TRB, 1990
6. NCHRP Synthesis 446. Use of Advanced Geospatial Data, Tools, Technologies, and Information in Department of Transportation Projects: A Synthesis of Highway Practice, TRB 2013.
7. Simlowitz HJ. GIS Support Transportation System Planning, International GIS Sources Book
8. TCRP Synthesis 55. Geographic Information Systems Applications in Transit: A Synthesis of Transit Practice, TRB, 2004.
9. Thill JC, GIS in Transportation, Transportation Research Part C, 2000.

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CE5663: INTELLIGENT TRANSPORTATION SYSTEMS
Course Type: Elective; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Identify and differentiate ITS user services and its components.
CO2	Select and provide appropriate ITS technology to solve real-life traffic problems.
CO3	Manage the traffic congestion by acquisition of big data using advanced devises.
CO4	Design and implement the suitable ITS and services for effective transportation.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		2	1	1						
CO2		3	2	2						
CO3		3	2	2				1	2	
CO4		1	1	1				1		

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

ITS Background and Telemetric systems:
Definitions, features and objectives of ITS, History of ITS and its development over the world, telemetric concept, transport telemetric, telemetric structure, ITS taxonomy, ITS application areas, uses, and application overview.

ITS User Services:
infrastructure based services; Arterial management and integration, freeway/highway management, crash prevention and safety, road weather management, roadway operation and maintenance, transit management, emergency management, Electronic payment and pricing, traveller information, COV, etc., Intelligent vehicle based services; collision notification and avoidance system, driver assistance system, and examples.

ITS components, tools and strategies:
Components of user services; advanced traffic management system, advanced traveler information system, advanced vehicle control system, commercial vehicle operational management, advanced public transportation system, electronic payment system, advanced rural transportations, security and safety systems, urban traffic control, scoot and scat systems, benefits and limitations.

Design and implementation:
Design components; data acquisition methods, equipment and used technology, radar and sensor, detectors, vehicle identifiers, and GPS, Communication tools; DSRC, CALM, traveler information tools, data handling, processing and management; TCM, and its working, worldwide ITS implementation and challenges, case studies.

ITS Standards and future scope:
ITS standards, development process, legal issues, financial issues, Mainstreaming ITS; integration and up gradation; Future of ITS, case studies.

READING:

1. AUSTROADS, The Implication of Intelligent Transport Systems for Road Safety, Austroads Incorporated, 1999.
2. Bob Williams, Intelligent Transport Systems Standards, Artech House Publishers, 2008.

3. Chowdhury, M. A. and Sadek, A, Fundamentals of Intelligent Transportation Systems Planning, Artech House, 2003.
4. E. Bekiaris and Y.J. Nakanishi, Economic Impacts of Intelligent Transportation Systems: Innovations and Case Studies, Elsevier/JAI, 2004.
5. IET Intelligent Transport Systems and 15th International IEEE Conference on Intelligent Transportation Systems (ITSC), 16-19 September, 2012. (http://digital-library.theiet.org/content/journals/iet-its)
6. J.M. Sussman, *Perspectives on Intelligent Transportation Systems* (ITS), Springer, 2005
7. L. Vlacic, M. Parent, F. Harashima, Intelligent Vehicle Technologies – Theory and Applications, Butterworth-Heinemann, 2010.
8. M.A. Chowdhury and A. Sadek, Fundamentals of Intelligent Transportation Systems Planning, Artech House, 2010.
9. R. Stough, Intelligent Transport Systems: Cases and Policies, Edward Elgar, 2001, Artificial Intelligence and Intelligent Transportation Systems, National Academy Press, 2010.

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CE5664: TRANSPORT LOGISTICS
Course Type: Elective; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Understand logistic systems and city logistics.
CO2	Model demand and supply for logistic systems.
CO3	Apply mathematical programming in modelling city logistics.
CO4	Perform different methods of optimizing logistics in urban areas.
CO5	Use ITS concepts in efficiently managing the logistics in urban areas.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		1	2	1	1	1				
CO2	3	3	2	2	1					
CO3	3	3	2	1	1			1		
CO4	3	1	1	1	1					
CO5	2	2	1	2				1		

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Introduction:
Modeling logistics; Demand and supply model; Mathematical programming; Inventory model, physical distribution networks.

Mathematical Programming for City Logistics:
Linear programming ; Non-linear programming; Application of linear and non-linear programming, vehicle routing.

Modeling of Logistics:
Aggregated demand forecast for city logistics; Disaggregated demand forecast for city logistics; Inventory model; Delivery scheduling, Transportation-inventory-production interrelationships, the role of transshipments and terminals in logistic systems for the transportation of goods and passengers.

Aggregated and disaggregated demand forecast for city logistics
Aggregated demand forecast; Disaggregated demand forecast.

Logistics optimization
Production scheduling; Delivery scheduling; Six sigma concepts; Product design optimization; Human resource management; Logistics optimization software.

Use of intelligent transportation systems in city logistics
Fundamental concepts, Data acquisition, data processing, information dissemination, geographic information systems, effects of e-commerce; Current ITS applications, evaluation issues

READING:

1. Alan C. McKinnon, Kenneth John Button and Peter Nijkamp, Transport Logistics Volume 5 of Classics in Transport Analysis Elgar Reference Collection, E. Elgar, 2002 (Digitised in 2011)
2. Bramel, J., and Levi, D. S., The Logic of Logistics: Theory, Algorithms, and Application for Logistics Management, Springer-Verlag, New York, USA, 1997.

3. Caplice, Chris, and Yossi Sheffi. *ESD.260J Logistics Systems, Fall 2006*. (MIT Open Courseware: Massachusetts Institute of Technology), http://ocw.mit.edu/courses/engineering-systems-division/esd-260j-logistics-systems-fall-2006 (Accessed 7 Jan, 2014). License: Creative Commons BY-NC-SA
4. Euro decision, Operational research, Logistics Optimization. http://www.eurodecision.eu/logistics-optimization
5. Harilaos N. Psaraftis Editor, Green Transportation Logistics: The Quest for Win-Win Solutions, Springer, 2016
6. Issa Baluch, Transport Logistics: Past, Present and Predictions, Winning Books, 2005 (Digitised in 2011)
7. Lambert, M. D., Srock, J. R., and Ellram, M. L., Fundamentals of Logistics Management, McGraw Hill International Editions, 1998.
8. Taniguchi, E., Thompson, R. G., Yamada, T., and Duin, R. V., City Logistics – Network Modelling and Intelligent Transport Systems, Pergamon, 2001.

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CE5665: OPTIMISATION TECHNIQUES IN TRANSPORTATION
Course Type: Elective; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Understand different optimisation techniques and simulation tools.
CO2	Solve linear, no-linear and dynamic programming problems.
CO3	Find feasible solution to transportation problems.
CO4	Application of advanced methods of optimization like Genetic Algorithm based optimization, Particle Swarm optimization, Simulated annealing, Ant colony optimization for Transportation specific problems.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3	2		1						
CO3	3	2		1						
CO4	3	2		1						

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Introduction and Classical Optimization Techniques:
Formulation of an optimization problem, constraint surface, objective function, objective function surfaces, classification of optimization problems, Single variable optimization, multi variable optimization without constraints, necessary and sufficient conditions for minimum/maximum, multivariable optimization with equality constraints.

Linear Programming:
Standard form of a linear programming problem, geometry of linear programming problems, definitions and theorems, system of linear simultaneous equations, pivotal reduction of a general system of equations, motivation to the simplex method, simplex algorithm, Use of software for solving linear optimization problems, graphical and simplex methods, Linear program network design model incorporating system optimal strategic dynamic traffic assignment.

Non-linear Programming:
One – dimensional minimization methods: Classification, Fibonacci method and Quadratic interpolation method, Univariate method, Powell's method and steepest descent method, Characteristics of a constrained problem, Classification, Basic approach of Penalty Function method; Basic approaches of Interior and Exterior penalty function methods. Introduction to convex programming problem, Applications in transportation network design.

Dynamic Programming:
Basics of dynamic programming, multistage decision processes – types, concept of sub optimization, the principle of optimality – computational procedure in dynamic programming – calculus method of solution - tabular method of solution, Mixed integer optimization, mixed integer dynamic programming model for optimal transportation network.

Transportation Problem:
Finding initial basic feasible solution by north – west corner rule, least cost method and Vogel's approximation method – testing for optimality of balanced transportation problems, Transportation problem with the help of dual simplex, Big M and two phase methods

Advanced methods of optimization:
Multi objective optimization – Weighted and constrained methods; Multi level optimization, Direct and indirect search methods, Evolutionary algorithms for optimization and search, Genetic Algorithm based optimization, Particle Swarm optimization, Simulated annealing, Ant colony optimization, Multi-objective optimization of highway alignment, Multi-objective Approach to Long-term Interurban Multi-level Road Network Planning, Parallel optimization for traffic assignment, Non-convexity of dynamic traffic assignment.

READING:

1. Deb K., Multi-Objective Optimization using Evolutionary Algorithms, First Edition, John Wiley & Sons Pvt. Ltd, 2002.
2. Dong HK, Ajith A, Jae HC; A hybrid genetic algorithm and bacterial foraging approach for global optimization; 2007
3. Dorigo M., and T. Stutzle, Ant Colony Optimization, Prentice Hall of India Pvt. Ltd., New Delhi, 2005.
4. Griffiths J.D., Mathematics in Transport Planning and Control: Proceedings of the 3rd IMA International Conference on Mathematics in Transport Planning and Control; Pergamon Publishers, 1998
5. Harvir Singh Kasana and Krishna Dev Kumar, Introductory Operations Research: Theory and Applications, Springer, 2004
6. Jorge Freire de Sousa and Riccardo Rossi, Editors, Computer-based Modelling and Optimisation in Transportation, Springer, 2014.
7. K. Srinivasa Raju and D. Nagesh Kumar, "Multicriterion Analysis in Engineering and Management", PHI Learning Pvt. Ltd., New Delhi, India, 2010.
8. Roger P. Roess, Elena S. Prassas, William R. McShane, Traffic Engineering, Pearson, 2011.
9. Saul I. Gass, Linear Programming: Methods and Applications, Fifth Edition, Dover Publications, Inc, Mineola, New York, 2003
10. SS Rao, Engineering optimization: Theory and practice, New Age International (P) Limited, 3rd edition, 1998.

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CE5666: PAVEMENT MANAGEMENT SYSTEM
Course Type: Elective; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses:
1. CE5603: Pavement Analysis and Design

Course Outcomes: *At the end of the course, students will be able to*

CO1	Identify and select suitable design strategies for a given pavement.
CO2	Determine the pavement condition using functional and structural methods.
CO3	Decide the type and timing of maintenance required for given pavement.
CO4	Evaluate and estimate the life cycle cost of pavements.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2	3	1	1	1		2	2	2	2
CO2	3	3	1			2			2	2
CO3	3	3	3	3			2	2	2	2
CO4	3	3	3	2			2	2	2	2

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Introduction to Pavement Management:
Historical perspectives of PMS, Evolution of PMS concepts, basic components of PMS, system, network and project levels of PMS, data Needs, GIS applications, database design, inventory and monitoring databases, planning pavement investments process, benefits of pavement management.

Pavement Performance Models:
General concepts, pavement evaluation with respect to user cost, , pavement evaluation technologies, techniques for developing prediction models deterministic, probabilistic, expert system of PMS models; remaining service life, AASHO, CRRI and HDM models, deterioration concepts and modelling, priority programming methods, pavement life cycle cost analysis, decision tree, PMS analysis software.

Design Alternatives:
Design Alternatives, evaluation and selection, framework for pavement design, design objectives and constraints, generating alternative pavement design strategies, methods of economic evaluation, economic evaluation of alternative pavement design strategies and selection of optimal design strategies.

Pavement Prioritization Techniques:
General concepts, ranking methods and procedures, prioritization based on befit cost ratio, mathematical optimization for prioritization of M, R&R Work Programs, Markov and heuristic approaches and ANN techniques for Prioritization of M, R&R Work programs.

Implementation of PMS and Technologies:
Major steps in Implementation of PMS, operational Issues, system complexity, feedback, other Institutional Issues and PMS case studies

READING:
1. Huang, Yang H. Pavement Analysis and Design. Prentice-Hall, Inc. Englewood Cliffs, New Jersey, 1993.

2. Hudson, W. R., R. Haas and W. Uddin. Infrastructure Management: Integrating Design, Construction, Maintenance, Rehabilitation, and Renovation. McGraw Hill. New York, 1997.
3. Proceedings of International Conference on Structural Design of Asphalt Pavements NCHRP, TRR and TRB Special Reports.
4. Proceedings of North American Conference on Managing Pavement, 1987, 1994.
5. Ralph C.G. Haas and Ronald W. Hudson, Pavement Management System, McGraw Hill Book Co. 1978.
6. Ralph C.G. Haas, W. Ronald Hudson and Zanieswki, Modern Pavement Management, Kreiger Publications, 1994.
7. Shahin, M.Y. Pavement Management for Airports, Roads and Parking Lots. Chapman & Hall, New York, 1994.
8. Southeast Michigan Council of Governments. Pavement Management System, SEMCOG, 1997.
9. Transportation Association of Canada. Pavement Design and Management Guide. Transportation Association of Canada, Ottawa, 1997.

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CE5667: PUBLIC TRANSPORTATION
Course Type: Core; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses:
1. CE5601: Urban Transportation Planning

Course Outcomes: *At the end of the course, students will be able to*

CO1	Understand the planning of transit system and network.
CO2	Design the transit network by considering all important parameters.
CO3	Measure the performance of transit route and scheduling of crew.
CO4	Model the integrated transit system and operational management.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		3								
CO2	2	3		3			2		3	
CO3	3			2	3	3	2	3		3
CO4	2	3	2	2	2		3	2	2	2

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Transit system:
Role of Transit - Types of Transit Modes - Buses - LRT, RTS - Air cushioned and Maglev System – S-Bahn Dual Mode Busses, Para Transit - Dial - a- Ride-Taxi- Jitney and Ridesharing – PRT Networks -DRTS Technological Characteristics – Resistances, acceleration & velocity Profiles – Operational characteristics speed, capacity & payloads – Route capacity – Comfort conditions - Performance relationships - Public and Private Operations - Modes for Intercity Transport.

Estimation of transit demand:
Data requirements & Collection techniques, Conventional Methods - Destination Survey - Bus Stop Surveys and Analysis - Mode Split Models - Captive and Choice Riders - Attitudes of Travellers - Patronage Determination.

Bus route network planning:
Route Systems - Route Location, Route Structure, Route Coding Techniques, Route Capacity - Planning of Transit Network - Different Types - Service Area Coverage - Evaluation - Selection of Optimal Network - Path Building Criteria - Integration with UTPS.

Scheduling:
Patterns of Bus Services - Frequency of Services - Special Services - Single Route Bus Scheduling - Fleet Requirement, Marginal Ridership Concept - Use of Optimisation Technique - Load Factor - Depot Location - Spacing of Bus Stops

Mass transit corridor identification & planning:
Corridor identification - Network Compression Method - Planning of Rapid Transit System - System Selection - Supporting and Enclosing Structures - System Evaluation - Track Structures - Power Supply and Distribution - Signal System - Aesthetics and Noise Consideration - Cost of Construction - Station Arrangements - Platform Capacity - Fare Collection, Transit Marketing.

Mass transport management measures:
RTC Act - ASRTU System Efficiency and Effectiveness Measures - Performance Indicators – LOPTS - Preferential Treatment to HOV: Exclusive Bus Lanes - Bus Streets - Contra Flows - Reversible Lanes - Bus Bypass - Bus Pre-emption Signals for Bus Operations.

TRANSIT TERMINALS AND PERFORMANCE EVALUATION:
Performance Evaluation – Efficiency, Capacity, Productivity and Utilisation – Performance Evaluation Techniques and Application – System Network Performance – Transit Terminal Planning and Design

READING:

1. Black, A, Urban Mass Transportation Planning, McGraw-Hill International Enterprises, Inc. 1995.
2. David A. Hensher, Bus Transport: Economics, Policy and Planning. Research in Transportation Economics Volume 18. Elsevier Publications, 2007.
3. G.E. Gray and CA Hoel, Public Transport Planning Operation and Management, Prentice Hall; 2nd Edition, 1992
4. John D. Edwards, Transportation Planning Handbook, Second Edition, Institution of Transportation Engineers, 1999.
5. Simpson, Barry J., Urban Public Transport Today. Taylor & Francis Routledge Publisher, 2003
6. Tiwari G., Urban Transport for Growing Cities – High Capacity Bus System, MacMillan India Ltd., 2002
7. Tyler N., Accessibility and the Bus System – Concepts and Practice, Thomas Telford, 2002.
8. Vuchic Vukan R., Urban Transit: Operations, Planning and Economics, Prentice Hall, 2005.
9. White, P., Public Transport: Its Planning, Management and Operation, Fourth Edition, London New York, 2002.

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CE5668: REGIONAL TRANSPORTATION PLANNING
Course Type: Elective; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Delineate regions for transportation planning.
CO2	Estimate demand for both regional and intercity passenger travel.
CO3	Estimate regional goods travel demand.
CO4	Plan and evaluate regional transportation networks.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	1	1	1							
CO2	3	2	2	1						
CO3	3	2	2	1						
CO4	1	3	3							

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Delineation of Regions:
Concept of Region, Types of regions, Hierarchy of activities & Issues Related to Regional Planning, Hierarchy of Regions, mega region development, Methods of Delineation Regions – Qualitative approaches – Quantitative approaches, Formal regions – weighted index method and factor analysis method; Functional regions – flow analysis & gravitational analysis.

Regional Passenger Travel Demand Estimation:
Comparison of Urban and Regional travel; Factors Affecting Passenger Flows, Use of Mathematical Models to Estimate Passenger Travel Demand, Direct Demand Models, Abstract Mode Models, Mode Specific Models, case studies.

Intercity Passenger Travel:
Definition of Intercity travel, dimensions of intercity travel decision making, aggregate and disaggregate models.

Regional Goods Travel Demand Estimation:
Factors Affecting Goods Flows; Characteristics of freight travel; Use of Mathematical Models to Estimate Freight Demand; Aggregate and disaggregate models – Freight Generation, trip distribution, mode choice & traffic assignment; Input – output model, MIT Model, etc.

Regional network planning:
Problems in Developing Countries, Network Characteristics - Circuitry, Connectivity, Mobility, Accessibility and Level of Service Concepts - Network Structures and Indices – Network Planning – Evaluation - Graph Theory – Cut sets – Flows & Traversing – Optimum Network - Inter-modal Co-ordination. Special features of low volume Roads – Rural Road Network Planning

READING:

1. C.J. Khisty and B. Kent Lall, Transportation Engineering, Prentice Hall of India Pvt. Ltd., 2002.
2. C.S. Papacostas and P.D. Prevedouros, Transportation Engineering and Planning, Prentice Hall of India Pvt. Ltd., 2001.

3. Der-Horng Lee, Editor, Urban and Regional Transportation Modeling: Essays in Honor of David Boyce, Edward Elgar, Cheltenham, UK, 2004
4. John D. Edwards, Transportation Planning Handbook, Second Edition, Institution of Transportation Engineers, 1999.
5. John W. Dicky, Et al, Metropolitan Transportation Planning, Second Edition, Taylor & Francis, 1983.
6. Meyer Kutz, Editor, Handbook of Transportation Engineering, McGraw Hill Handbooks, 2004.
7. Wilson, A.G., Regional and Urban Models in Geography and Planning, Pion Press.

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CE5669: ROAD ASSET MANAGEMENT
Course Type: Elective; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses:
1. CE5602: Traffic Analysis
2. CE5603: Pavement Analysis and Design

Course Outcomes: *At the end of the course, students will be able to*

CO1	Explain principles and concepts of asset management.
CO2	Develop Highway Inventory systems.
CO3	Develop Financial Management and workforce management systems.
CO4	Develop Construction Management and Safety Management Systems.
CO5	Develop Bridge Management System.
CO6	Develop Pavement Management & Highway Maintenance Management Systems.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	1		2					3		
CO2	1		2					3	1	
CO3	1		2					3	1	
CO4	1		2					3	1	
CO5	1		2					3	1	
CO6	1		2					3	1	

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Highway Asset Management:
Principles, types of asset management definition, structure, historical background, elements of highway asset management, asset Inventory, activity and cost model development, public assets versus private assets, motivation for asset management, benefits of road asset, management system, financial management systems, roads billing, roads payment and cost accounting and tools for asset management.

Highway Asset Valuation and Frame Work:
Asset Valuation approaches, guidelines, overview of highway asset valuation procedure, valuation principles, basis and rules, depreciation, highway lighting and high mast lighting, land associated with the highways.

Construction Management Systems:
Preconstruction scheduling, utility management, ROW management, user occupancy permits, project control, agreement monitoring and contractor management.

Roadway Operations Management Systems:
Joint operations center, district operations center, traveler information systems.

Bridge Management Systems:

Bridge inventory and rating, bridge management.

Workforce Management Systems:
Payroll detail, personal information, employee accident.

Safety Management Systems:
Accident records, hazardous location, sight restriction inventory, highway safety information.

Roadway Operations Management Systems:

Joint operations center, district operations center, traveler information systems.

Equipment Management Systems:

Equipment management information, fleet management.

READING:

1. AASHTO Transportation Asset Management Guide: A Focus on Implementation, AASHTO, 2011.
2. Hamilton, W.E. *Transportation: Asset Management*, House Fiscal Agency, 2001.
3. NCHRP Report 551. Performance Measures and Targets for Transportation Asset Management, TRB, 2006.
4. NCHRP Report 632. An Asset-Management Framework for the Inter State Highways, TRB, 2009.
5. NCHRP Synthesis 439. Use of Transportation Asset Management Principles in State Highway Agencies, TRB, 2013.
6. NHS. *Transportation Asset Management*, Federal Highway Administration, National Highway Institute, USA, 2003.
7. OECD. *Asset Management for the Roads Sector*, Organization for Economic Co-operation and Development, France, 2001.
8. Thompson, P.D. *AASHTO Transportation Asset Management Guide: A Focus on Implementation*, USA, 2011.

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CE5670: TRAFFIC FLOW MODELLING AND SIMULATION
Course Type: Elective; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses:
1. CE5602: Traffic Analysis

Course Outcomes: *At the end of the course, students will be able to*

CO1	Develop traffic stream models.
CO2	Pedestrian stream modelling and analysis.
CO3	Analysis of shockwaves.
CO4	Analyse traffic queuing systems.
CO5	Simulate traffic at mid blocks and intersections.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3		1				
CO2	3	3	3	3		1				
CO3	3	3	3	3		2			2	
CO4	3	3	3	3		2			2	
CO5	3	3	3	3		1				

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Traffic Flow Modeling:
Traffic flow modeling approaches; Advanced Traffic Sensing Technologies, Mesoscopic modeling approach; Gas-kinematic models; Hybrid Simulation. Microscopic models: Safety-distance, Psycho-physical models, Optimal velocity, Neural network models, Fuzzy based models, Lane changing models; Discretionary and Mandatory; Gap acceptance models; Psychology and Traffic Control Interactions. Non-lane based behaviour modelling, Multi-scale modelling approach, Picoscopic modelling.

Pedestrian Flow Modeling:
Pedestrian behavior; Pedestrian interactions; Pedestrian facilities; Pedestrian behavioral models; Social-force models; Pedestrians simulation; Pedestrian stream models.

Shockwave Analysis:
Shock wave equations; Types of shockwaves and propagation; Shock waves at toll gates, Signalized intersections, Shockwaves due to incidents; Shockwave analysis on flow-density diagram and using simulation.

Queuing Analysis:
Queue discipline and Queuing patterns; Deterministic Queuing analysis; Stochastic queuing analysis; Single channel; Multiple channels; Moving queues; Queuing examples and numerical analysis; Determination of number of servers, Average time and vehicles in Queuing system.

Simulation Methodologies:
Monte Carlo method; Generation of Pseudorandom Numbers; Discrete Random deviates; Simulation methods; Fundamentals of simulation, Introduction to factorial experimental designs, Fractional factorial design, Components of traffic simulations models, vehicle arrival and movement models, mixed traffic flow simulation, Simulation model development strategies; Study of large scale simulation models; Scanning Technique; Time based and Even-based methods; Examples of Macro, Meso, and Microscopic based simulation models.

Calibration and Validation of Simulation Models:
Simulation scenario evaluation, Number of runs and factors influencing simulation output, Calibration and validation definitions, methodology for calibrating and validating a microscopic traffic simulation model. Calibration and validation guidelines, data requirements, Goodness-of-fit measures; Case studies of application of simulation for various transportation engineering problems.

READING:

1. Banks, J; Carson, JS; Nelson, B.L. Discrete-event system simulation. 5th ed. Upper Saddle River, NJ: Prentice-Hall, 2010.
2. Barceló, J. "Models, Traffic Models, Simulation, and Traffic Simulation". Barceló, J. ed. Fundamentals of traffic simulation. New York: Springer, 2010.
3. Boris S. Kerner, Introduction to Modern Traffic Flow Theory and Control, Springer; 1st Edition. Edition, 2009
4. Drew, DR., Traffic flow theory and control McGraw Hill Book Company, 1976.
5. Fred L. Mannering, Scott S. Washburn, Kilareski Walter P., Principles Of Highway Engineering And Traffic Analysis, Wiley India Pvt Ltd., 4th edition, 2011.
6. Gerlough DL and Huber MJ. Traffic Flow theory A Monograph: TRB special report 165, 1992.
7. Highway Capacity Manual, Transportation Research Board, Washington, D.C., 2010.
8. May, A.D. Traffic Flow Fundamentals, Prentice Hall, 1st Edition, 1990.
9. Mc Shane WR and RP Roess: Traffic Engineering Prentice Hall, 1998.
10. Roger P. Roess, E. S. Prassas and W. R. McShane, Traffic Engineering, Prentice Hall, 4th edition, 2010.

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CE5671: TRANSPORT ECONOMICS AND PROJECT APPRAISAL
Course Type: Core; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses: Nil

Course Outcomes: *At the end of the course, students will be able to*

CO1	Estimate road user cost.
CO2	Perform economic analysis of a transportation project.
CO3	Evaluate alternate transportation project proposals.
CO4	Carryout life-cycle cost analysis of transportation projects.
CO5	Assess the funding model for infrastructure projects.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2	3		1			1	1		2
CO2	2	3		1			2	2	1	2
CO3	2	2	2	1					1	2
CO4	2	2		1						3
CO5		3	1					3	1	2

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Introduction to transport economics:
Basic components of transport economics, review of engineering economics, elements of engineering economics, and microeconomics, welfare theory and equilibrium conditions, goals and objectives, principles of economic analysis.

Methods of economic analysis:
Discounted cash flows: analysis of user costs and benefits, RUCS models for costs and benefits, methods of economic analysis; suitability, analysis for null alternative, mechanisms to deal with traffic congestion and congestion pricing.

System selection and evaluation:
Framework of evaluation, transport planning evaluation at urban and regional levels, other evaluation procedures - traditional economic analysis, achievement matrices, factor profiles, plan ranking, introduction to mathematical programming, case studies.

Transportation project appraisal and evaluation:
Feasibility and evaluation, cost, impacts and performance levels, evaluation of alternatives, analysis techniques, cost benefit analysis, social and financial benefits, Internal Rate of return method for economic and financial viability, valuation of time, measures of land value and consumer benefits from transportation projects, prioritization of projects, multi-criteria decision assessment, LCCA and Role of HDM in feasibility studies.

READING:

1. C.G. Swaminathan and L.R. Kadiyali, Road User Cost Study in India, Central Road Research Institute, New Delhi, 1983.
2. Elena S. Prassas and Roger P. Roess, Engineering Economics and Finance for Transportation Infrastructure, Springer, 2013
3. Highway investment in Developing countries; Commission of the European Communities, Institute of Civil Engineers, Thomas Telford Ltd 1983.
4. Ian Graeme Heggie, Transport Engineering Economics, McGraw Hill, 1972.
5. John W. Dickey and Leon H. Miller, Road Project Appraisal for Developing countries, John Wiley and Sons., 1984.
6. Kadiyali LR, Traffic Engineering and Transport Planning, Khanna Publishers, 1997.

7. Kenneth Button, Transport Economics, 3rd Edition, Edward Elgar, Cheltenham, UK, 2010
8. Michael J Markow, Engineering Economic Analysis Practices for Highway Investment, NCHRP Synthesis 424, TRB, 2012
9. Robley Winfrey, Economic Analysis for Highways - International Text Book Co., Pennsylvania, 1969 (Digitised in 2011)
10. Vinay Maitri and P.K Sarkar, Theory and Applications of Economics in Highway and Transport Planning, Standard Publishers Distributors, First Edition 2010.

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CE5672: TRANSPORTATION NETWORK ANALYSIS
Course Type: Elective; Instruction: L-T-P-C: 3-0-0-3

Pre Requisite Courses:
1. CE5601: Urban Transportation Planning

Course Outcomes: *At the end of the course, students will be able to*

CO1	Apply different traffic assignment techniques.
CO2	Estimate Trip tables.
CO3	Determine network reliability.
CO4	Design transportation networks.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	1		1				
CO2	3	3								
CO3	2	2				1		2		
CO4	2	3	1	1		1				

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Introduction:
Networks representation, Network equilibrium, Link and Cost Functions, Incidence matrices, Network capacity, Shortest path algorithm.

Optimality and cost functions:
Matrix operations, Objective functions, Traffic representation, Junctions costs, Priority junctions, Signal controlled junctions.

Assignments techniques:
User Equilibrium – Existence and Uniqueness, Deterministic user equilibrium assignment, Most Likely paths, Elastic demand, Time Dependent Networks, stochastic user equilibrium assignment, User Equilibrium with variable demand models, Space-time networks, Case Studies.

Trip Table Estimation:
Maximum entropy, Generalised least squares, Linear path-flow estimations, Log-linear path-flow estimations, Time-dependent methods, Case Studies.

Network reliability:
Connectivity, Structure functions and reliability value, Heuristic methods, Travel time reliability; Considerations of sample size; experiment design for demand forecasting and transportation operations analysis.

Network design:
Bi-level programming-Iterative design, Sensitivity based algorithm, Sensitivities of user equilibrium and stochastic user equilibrium methods. Combined trip distribution and assignment, Combined mode choice and assignment, discrete choice models, Application to route choice, Estimating OD matrices, Estimating demand functions, Theory of congestion pricing, Path flows and link flows, Path-based and origin-based methods.

READING:
1. Ahuja R., T. Magnanti, and J. Orlin. Network Flows; Prentice Hall, 1993.

2. Marc Bernot, Vicent Caselles and Jean-Michel Morel, Optimal Transportation Networks: Models and Theory, Springer, 2009
3. Michael Alexander Florian, Michel Gendreau, Patrice Marcotte. Transportation and network analysis: current trends: miscellanea in honor of Michael Florian; Springer Publisher, 2002.
4. Michael G.H. Bell and Chris Cassir, Reliability of Transport Networks, Research Studies Press, 2000.
5. Michael G.H. Bell and Yasunori Lida. Transportation Network Analysis, J. Wiley Publishers, 1997.
6. Michel Gendreau and Patrice Marcotte (Editors), Transportation and Network Analysis: Current Trends, Miscellanea in honor of Michael Florian, Springer-Science+Business Media, B.V., 2002
7. OECD and International Transport Forum, Improving Reliability on Surface Transport Networks, OECD, 2010
8. William R. Black, Transportation: A Geographical Analysis, The Guilford Press, New York, 2003
9. Yosef Sheffi. Urban Transportation Networks: Equilibrium Analysis with Mathematical Programming Methods, Prentice Hall Publishers, 1985.

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M.Tech (Transportation Engineering), III Semester

CE6642: COMPREHENSIVE VIVA VOCE
Course Type: Core; Instruction: L-T-P-C: 0-0-0 (2)

Pre Requisite Courses:
Both I & II Semester course work of I Year should be completed.

Course Outcomes: *At the end of the course, students will be able to*

CO1	Assimilate knowledge of different courses studied.
CO2	Develop overall comprehension about Transportation Engineering.
CO3	Analyse real life transportation problems with theoretical knowledge learned.
CO4	Interpret and Articulate solutions to real life transportation problems.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2	2	2			1				
CO2	2	2	2			1				
CO3	2	3	2			2				
CO4	1	2	3			1				

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:
Entire course of study (All the required courses studied) up to II Semester of I Year.

READING:

1. Reading Material of all the courses.
2. Case Studies / Consultancy Reports.

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CE6649: DISSERTATION Part - A
Course Type: Core; Instruction: L-T-P-C: 0-0-0 (6)

Pre Requisite Courses:
Both I & II Semester course work of I Year should be completed.

Course Outcomes: *At the end of the course, students will be able to*

CO1	Define Research Problem Statement.
CO2	Critically evaluate literature in chosen area of research & establish Scope of work.
CO3	Develop Study Methodology.
CO4	Carryout Pilot Study.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1			1	3		3				
CO2			1	3		3				
CO3	2	2	2	3		3				
CO4	3	3	1	3		3				

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:
There is no prescribed syllabus. Students are required to search, collect and review various research articles published in chosen area of research. A student has to select a topic for his dissertation, based on his/her interest and the available facilities at the commencement of dissertation work. A student shall be required to submit a dissertation report on the research work carried out by him/her.

READING:

1. Conference / Seminar Proceedings.
2. Derek Swetnam, Writing Your Dissertation, 3rd Edition, Oxford, UK, 2004.
3. Handbooks / Research Digests.
4. Journal Publications.

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M.Tech (Transportation Engineering), IV Semester

CE6699: DISSERTATION Part - B
Course Type: Core; Instruction: L-T-P-C: 0-0-0 (12)

Pre Requisite Courses:

1. Both I & II Semester course work of I Year should be completed.
2. CE6649: Dissertation Part A.

Course Outcomes: *At the end of the course, students will be able to*

CO1	Define Research Problem Statement.
CO2	Critically evaluate literature in chosen area of research & Establish Scope of work.
CO3	Develop Study Methodology.
CO4	Conduct Laboratory / Field Studies.
CO5	Analyse Data, develop models and offer solutions.

Mapping of the Course Outcomes with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1			1	3		3				
CO2			1	3		3				
CO3	2	2	2	3		3				
CO4		1		3						
CO5	2	3	3	3		3				

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

There is no prescribed syllabus. Students are required to search, collect and review various research articles published in chosen area of research. A student has to select a topic for his dissertation, based on his/her interest and the available facilities at the commencement of dissertation work. A student shall be required to submit a dissertation report on the research work carried out by him/her.

READING:

1. Conference / Seminar Proceedings.
2. Derek Swetnam, Writing Your Dissertation, 3rd Edition, Oxford, UK, 2004.
3. Handbooks / Research Digests.
4. Journal Publications.

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