NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

RULES AND REGULATIONS

SCHEME OF INSTRUCTION AND SYLLABI

for M.Tech. Program in Transportation Engineering

(Effective from 2021-22)

DEPARTMENT OF CIVIL ENGINEERING

Vision and Mission of the Institute
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 the globally competitive environment.
- Allowing stakeholders 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 center to serve the societal needs.

Vision and Mission of the Department
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 the 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.

Department of Civil Engineering:

Brief about the Department:

The Department of Civil Engineering was established in 1959, along with the setting up of the institute, that is, REC Warangal. The Department offers undergraduate and eight postgraduate programs in addition to Ph.D. The Department has highly committed faculty who are well qualified and are members of several national and international policy making and advisory bodies, including the BIS. The Department is a recognized QIP center since 1978 to offer Ph.D. programs to faculty of other institutes. The Department is known for its cutting-edge research and believes in disseminating the knowledge through publishing in highly reputed journals and patenting the research work.

The Department maintains excellent industry-institute linkages. Most of the students are placed in reputed companies, Government organizations, and Higher Educational Institutes in India and abroad. The alumni who are important stakeholders of the Department actively guide and provide valuable inputs. They constantly peer review the syllabus and curriculum to make students industry-ready.

The Civil Engineering Department, apart from Teaching and R&D, also does an enormous amount of consultancy, which adds up to the institutional internal revenue generation and involves faculty and students in challenging field problems. There are six centers of excellence in the Department, and most laboratories have state-of-the-art equipment.

The faculty of the Department are actively involved in sponsored projects and have prestigious projects like SPARC, BRICS, IMPRINT, DST, SERB, DBT, ARDB, to name a few. The Department takes pride in having conducted the highest number of GIAN and SPARC programs.

The Civil Engineering Department has MoUs with highly reputed organizations like NAAC, NCCBM, WALAMTARI, SCCL, INVENTA, PSI, among others, and has collaborations with several foreign universities and companies such as – Texas A&M, NCAR-Colorado, PTV Group Germany, etc.

List of Programs offered by the Department:

Program	Title of the Program
B.Tech.	Civil Engineering
M.Tech.	Engineering Structures
	Water Resource Engineering
	Geotechnical Engineering
	Transportation Engineering
	Remote Sensing and Geographical Information Systems
	Environmental Engineering
	Construction Technology and Management
	Waste Management
Ph.D.	Civil Engineering

Note: **Refer to the following weblink for Rules and Regulations of M.Tech. program:**
https://www.nitw.ac.in/main/MTechProgram/rulesandregulations/

NATIONAL INSTITUTE OF TECHNOLOGY, WARANGAL
DEPARTMENT OF CIVIL ENGINEERING

MTech Program in TRANSPORTATION ENGINEERING

Program Educational Objectives (PEOs)

The graduating students of the Transportation Engineering program 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 competent professionals to fit into a broad range of career opportunities available in the 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 society with an understanding of professional ethics and social responsibility.

Program Articulation Matrix-1

PEO / Mission Statements	PEO1	PEO2	PEO3	PEO4	PEO5
Generate a specialized cadre of civil engineers by imparting quality education and training.	**3**	**3**	**2**	**2**	**3**
Attain international standards in teaching, research, and consultancy with global linkages.	**3**	**3**	**2**	**3**	**2**

Note: 1-Slightly; 2-Moderately; 3-Substantially

NATIONAL INSTITUTE OF TECHNOLOGY, WARANGAL
DEPARTMENT OF CIVIL ENGINEERING

MTech Program in TRANSPORTATION ENGINEERING

Program Outcomes (POs)

At the end of the Transportation Engineering program, the graduating students will be able to:

PO1	Engage in critical thinking and pursue research/investigations to evolve solutions for multi-faceted real-life problems.
PO2	Communicate effectively on complex engineering activities with the engineering community and society at large, write and present technical reports.
PO3	Demonstrate a higher level of professional skills to tackle multidisciplinary and complex problems related to Transportation Engineering.
PO4	Plan, analyze, design, synthesize, execute, and manage complicated transportation infrastructure projects within a local and global context in a sustainable manner.
PO5	Provide cost-effective and technology-driven solutions for transportation-related societal problems, with good professional and ethical responsibility.
PO6	Function as a member of a multi-disciplinary team and to assume a leadership role in executing transportation infrastructure projects while updating skill sets required continuously throughout the professional life

Program Articulation Matrix-2

PO / PEO	PO1	PO2	PO3	PO4	PO5	PO6
PEO1	**3**	**1**	**3**	**3**	**3**	**1**
PEO2	**3**	**1**	**3**	**3**	**3**	**1**
PEO3	**1**	**3**	**1**	**2**	**1**	**3**
PEO4	**2**	**3**	**1**	**2**	**2**	**3**
PEO5	**3**	**1**	**2**	**2**	**3**	**1**

SCHEME OF INSTRUCTION
MTech (Transportation Engineering): Course Structure
I Year MTech (TE) I – Semester

S.No.	Course Code	Course Title	L	T	P	C	Cat. Code
1	CE5601	Urban Transportation Planning	3	0	0	3	PCC
2	CE5602	Traffic Analysis and Design	3	0	0	3	PCC
3	CE5603	Characterization of Pavement Materials	3	0	0	3	PCC
4	CE5604	Transportation Data Analysis	3	0	0	3	PCC
5		Elective – I	3	0	0	3	PEC
6		Elective – II	3	0	0	3	PEC
7	CE5605	Traffic Measurements Laboratory	0	1	2	2	PCC
8	CE5606	Transportation Analytics Laboratory	0	1	2	2	PCC
9	CE5648	Seminar-I	0	0	2	1	SEM
		TOTAL	**18**	**2**	**6**	**23**	

List of Professional Elective Courses in I Year I Semester (Electives – I & II)#

S.No.	Course Code	Course Title
1	CE5611	Airport Infrastructure Planning and Design
2	CE5612	Environmental Impacts of Transportation
3	CE5613	Highway Construction Practices
4	CE5614	Low Volume Road Engineering
5	CE5615	Optimization Methods in Transportation
6	CE5616	Pavement Drainage Systems
7	CE5617	Regional Transportation Planning
8	CE5618	Road Asset Management
9	CE5619	Traffic Control and Management
10	CE5620	Transport Policy and Financing
11	CE5621	Transportation Systems Management
12	CE5622	Waterway Infrastructure Planning and Design

In addition to the above courses, students can take courses offered from other specializations in the department.

I Year MTech (TE) II – Semester

Sl. No.	Course Code	Course Title	L	T	P	C	Cat. Code
1	CE5651	Land Use and Transportation Planning	3	0	0	3	PCC
2	CE5652	Geometric Design of Transportation Facilities	3	0	0	3	PCC
3	CE5653	Pavement Analysis and Design	3	0	0	3	PCC
4	CE5654	Road Safety Engineering	3	0	0	3	PCC
5		Elective – III	3	0	0	3	PEC
6		Elective – IV	3	0	0	3	PEC
7	CE5655	Pavement Materials and Evaluation Laboratory	0	1	2	2	PCC
8	CE5656	Transportation Software Laboratory	0	1	2	2	PCC
9	CE5698	Seminar – II	0	0	2	1	SEM
		TOTAL	**18**	**2**	**6**	**23**	

List of Professional Elective Courses in I Year II Semester (Electives III & IV)*

S.No.	Course Code	Course Title
1	CE5661	Advanced Travel Demand Modelling
2	CE5662	Big Data Analytics in Transportation
3	CE5663	GIS for Transportation Systems
4	CE5664	Intelligent Transportation Systems
5	CE5665	Logistics and Freight Transportation Systems
6	CE5666	Pavement Evaluation and Rehabilitation
7	CE5667	Public Transportation Systems
8	CE5668	Railway Infrastructure Planning and Design
9	CE5669	Sustainable Transportation
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 can take courses offered from other specializations in the department.

II Year MTech (TE) I – Semester

Sl. No.	Course Code	Course Title	L	T	P	C	Cat. Code
1		Industrial Training (8-10 weeks) Optional	-	-	-	-	-
2	CE6647	Comprehensive Viva- Voce	-	-	-	2	CVV
3	CE6649	Dissertation Part – A	-	-	-	12	DW

II Year MTech (TE) II – Semester

Sl. No.	Course Code	Course Title	L	T	P	C	Cat. Code
1	CE6699	Dissertation Part – B	-	-	-	20	DW

Credits Distribution

Sl. No.	Courses	No. of Courses Offered					Credits
		I Year		II Year		Total	
		I Sem	II Sem	I Sem	II Sem		
A	**Professional Core Courses (PCC)**						
1.	Theory Courses	4	4	-	-	8	24
2.	Laboratory Courses	2	2	-	-	4	8
	Sub Total	**6**	**6**	**-**	**-**	**12**	**32**
B	**Professional Elective courses (PEC)**						
	Theory Courses	**2**	**2**	**-**	**-**	**4**	**12**
C	**Comprehensive Viva-Voce (CVV)**	**-**	**-**	**1**	**-**	**1**	**2**
D	**Dissertation Work (DW)**	**-**	**-**	**A**	**B**	**2**	**32**
E	**Seminars – I & II (SEM)**	**1**	**1**	**-**	**-**	**2**	**2**
	Grand Total	**9**	**9**	**2**	**1**	**21**	**80**

Abbreviations:

PCC – Professional Core Courses
PEC – Professional Elective Courses
SEM – Seminars
CVV – Comprehensive Viva Voce
DW – Dissertation Work

DETAILED SYLLABUS

MTech (Transportation Engineering)

I Semester

CE5601	URBAN TRANSPORTATION PLANNING	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

CO1	Identify urban transportation problems.
CO2	Develop data base for calibration of travel demand models.
CO3	Estimate urban travel demand.
CO4	Plan urban transport networks.
CO5	Identify urban transport corridors and prepare urban transportation plans.

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

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; Smart Cities, Service Level Benchmarks.

Travel Demand Approaches:

Trends, Overall Planning process, Long term Vs. Short-term planning, Types of Plans, Master Plans, Demand Function, Independent Variables, Travel Attributes, Assumptions in Demand Estimation, Sequential, and Simultaneous Approaches, Aggregate and Disaggregate Techniques, UTPS Approach.

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:

Trip Generation Analysis: Zonal Models, Category Analysis, Household Models, Trip Attraction models, Commercial Trip Rates.

Trip Distribution:

Trip Distribution: Growth Factor Methods, Gravity Models, Opportunity Models, Time Function Iteration Models.

Mode Split:
Mode Choice Behaviour, Competing Modes, Mode Split Curves, Models, and Probabilistic Approaches.

Traffic Assignment:
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.

Corridor Identification - Plan Preparation and Evaluation:
Selection of Corridor, Corridor Identification, Corridor deficiency Analysis; Multimodal Transportation Planning, TOD; Travel Forecasts to Evaluate Alternative Improvements, Impacts of New Development on Transportation Facilities; Pivot Point Analysis, Environmental and Energy Analysis.

Learning Resources:

Textbooks:

1. Transportation Engineering and Planning; Papacostas, C.S. and Prevedouros, P.D., Prentice Hall of India Pvt. Ltd., 2012, Third Edition.
2. Transportation Engineering, Khisty C.J. and B Kent Lall; Prentice Hall of India Pvt. Ltd., 2012, Third Edition.
3. Urban Transportation Planning Lecture Notes, Chari, S.R., REC Warangal, 1990.

Reference Books:

1. An Introduction to Transportation Planning, Michael J. Bruton,Routledge Library Editions: Global Transport Planning, 2021.
2. Modelling Transport, Ortuzar J de D and LG Willumsen, John Wiley and Sons, 2011, Fourth Edition.
3. Principles of Urban Transportation System Planning, Hutchinson BG, Hutchinson, Allen,Taylor & Francis, 1986.
4. Transportation Planning Handbook, Michael D. Meyer, Institute of Transportation Engineers, John Wiley & Sons, 2016, Fourth Edition.
5. Urban Transportation Planning: A Decision-oriented Approach, Mayer MD and Miller EJ; McGraw Hill, 2001, Second Edition.
6. Urban Transportation: Planning, Operation and Management, Johnson Victor D., Ponnuswamy, S., Tata McGraw-Hill Education, 2012.

Online Resources:

1. http://www.nptelvideos.in/2012/11/urban-transportation-planning.html
2. https://nptel.ac.in/courses/105107067/
3. https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-252j-urban-transportation-planning-fall-2016/
4. https://olc.worldbank.org/content/integrated-urban-transport-planning-self-paced

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CE5602	TRAFFIC ANALYSIS AND DESIGN	3-0-0: 3

Pre-Requisites: **NIL**

Course Outcomes:

At the end of the course, students will be able to

CO1	Estimate essential characteristics of the traffic stream.
CO2	Explore various methods of traffic data collection.
CO3	Model traffic stream behavior at the micro and macro level.
CO4	Determine the capacity of highways.

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Components of Traffic System:

Introduction to Traffic Engineering, Human-Vehicle-Road User-Environment system, Characteristics of road users, characteristics of vehicles, Characteristics of Pedestrians.

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, Drone video analysis, Sample selection; Region traffic counts.

Characteristics of Traffic:

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

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; Platoon diffusion.

Microscopic Traffic Stream Models:

Car-following models: Stimulus-response; Distance-based models; Psycho-physical models, Neuro-Fuzzy models; Gap acceptance models; Mixed traffic flow behavior: Non-lane based movement and challenges of modeling Indian mixed traffic, Heterogeneity in traffic.

Highway Capacity Analysis:

Capacity and level of service concepts; Factors affecting capacity and LOS; Two-lane, Freeway, and multi-lane capacity analysis; Capacity of Urban arterials; Design and Capacity analysis of Signalized Intersections; US Highway Capacity Manual (HCM) and IRC standards, Indo-HCM standards.

Design of Signalized Intersections:
Warrants for signalization, design control variables, lost time estimation, saturation flow rate and capacity, dilemma zone analysis, signal timing design methods, pedestrian considerations, queue length and control delay, signal coordination for urban streets, adaptive traffic signals, design examples.

Learning Resources:

Textbooks:

1. Principles of Transportation Engineering, Partha Chakraborty, and Animesh Das, PHI Learning, 2017, Second Edition.
2. Traffic Engineering and Transportation Planning, Kadiyali L.R., Khanna Publishers, 2011, Ninth Edition.
3. Traffic Flow Fundamentals, May, A.D., Prentice Hall, 1990 (Digitized in 2007).

Reference Books:

1. Guidelines on Design and Installation of Road Traffic Signals, IRC:93, Indian Roads Congress, New Delhi, 1985.
2. Highway Capacity Manual, Transportation Research Board, Washington, DC, 2010.
3. Indian Highway Capacity Manual (INDO-HCM), Chandra, Satish, Gangopadhyay, S, Velmurugan, S, Ravinder, Kayitha, CSIR-CRRI, 2017.
4. Principles of Highway Engineering and Traffic Analysis, Fred L. Mannering, and Scott S. Washburn, Jhon Wiley & Sons, 2013, Fifth Edition.
5. Traffic and Highway Engineering, Nicholas J. Garber, and Lester A. Hoel, Cengage Learning India, 2015, Fifth Edition.
6. Traffic Engineering Design: Principles and Practice, Mike Slinn, Peter Guest, Paul Matthews, Butterworth-Heinemann, 2005, Second Edition.
7. Traffic Engineering, Roger P. Roess, Elena S. Prassas, and William R. McShane, Pearson, 2019, Fifth Edition.
8. Traffic Engineering: Theory and Practice; Pignataro L.J., Prentice Hall, Inc., 1973 (Digitized in 2011)
9. Transportation Engineering, Khisty C.J., and Kent Lall, B., Prentice Hall of India Pvt. Ltd., 2012, Third Edition.

Online Resources:

1. https://nptel.ac.in/courses/105/101/105101008
2. https://nptel.ac.in/courses/105/104/105104098
3. https://www.classcentral.com/course/edx-intro-to-traffic-flow-modeling-and-intelligent-transport-systems-12728
4. https://www.crridom.gov.in/sites/default/files/Indo-HCM%20Snippets.pdf
5. https://www.monash.edu/engineering/its/publications/tem2017

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CE5603	CHARACTERIZATION OF PAVEMENT MATERIALS	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

CO1	Identify different pavement materials.
CO2	Apply appropriate tests to characterize pavement materials.
CO3	Characterize various material inputs for different pavement design procedures.
CO4	Develop suitable performance tests and material specifications.

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Introduction to Pavement Materials:

Pavement structure; introduction to materials used in different layers; factors affecting pavement performance; need for material characterization; performance data collection; specification development.

Subgrade Soil and Stabilization:

Characterization of subgrade soil for pavement design: index properties, compaction characteristics; stiffness and strength of soil, resilient modulus (M_r); deformation characteristics of subgrade soil; soil Stabilization concepts: mechanical and chemical; geosynthetic application in pavements.

Aggregates:

Origin, physical characterization of aggregates; requirement of aggregate property in different pavement layers: aggregate gradations; aggregate packing characteristics; factors affecting the performance of unbound aggregate layers; non-linear behavior of granular materials; Mr-θ relationship; permanent deformation behavior of unbound aggregate layers; recycled aggregates and Marginal aggregates in pavement construction.

Bituminous Binder:

Types; constitution and structure of bitumen; requirements of paving grade binder; physical characterization; aging phenomena; rheology of bitumen: concept of linear viscoelasticity; rheological characterization of binders, binder grading: penetration, viscosity, and performance grading; performance tests to assess rutting, cracking, healing and aging susceptibility; binder performance specifications, rheological modeling of performance tests; chemical characterization of bitumen: FTIR, SARA analysis, bituminous emulsion, and cutbacks.

Bituminous Mix Design and Performance Tests:
Objectives of bituminous mix design; volumetrics of compacted bituminous mixes; Marshall mix design; Superpave mix design; Balanced mix design concept; mixture performance tests: resilient and dynamic modulus, permanent deformation, fatigue cracking, non-load associated cracking, moisture-induced damage; specification development; rap mix design; cold mix design.

Cement and Cement Concrete:
Cement-chemical composition, physical properties, admixtures; physical properties of cement concrete related to pavement application; design of cement concrete for pavements; fatigue models; special types of cement concrete: polymer concrete composites, sulphur concrete composites, fiber reinforced concrete, ferrocement, roller compacted concrete, and high strength concrete.

Learning Resources:

Textbooks:

1. Hot Mix Asphalt Materials, Mixture Design and Construction, Brown, E.R., Kandhal, P. S., Roberts, F.L., Kim, R., Lee, D-Y., NAPA Store, 2016, Third Edition.
2. Pavement Design and Materials, Papagiannakis, A.T., Masad, E.A., Wiley, 2008, First Edition.

Reference Books:

1. Asphalt Binder Handbook, MS-26, Asphalt Institute, 2011, First Edition.
2. Asphalt Mix Design Methods, MS-2, Asphalt Institute, 2015, Seventh Edition.
3. Bituminous Road Construction in India, Kandhal, P.S., PHI Learning Pvt.Ltd, 2016, First Edition.
4. Specifications for Road and Bridge Works, Ministry of Road Transport and Highways, Indian Roads Congress, New Delhi, India, 2013, Fifth Edition.
5. The Shell Bitumen Handbook, Hunter, R.N., Andy, S., John, R., ICE Publishing, 2015, Sixth Edition.

OnlineResources:

1. https://www.pavementinteractive.org/
2. https://www.eng.auburn.edu/research/centers/ncat/research/other-publications.html
3. https://nptel.ac.in/courses/105/106/105106203/

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CE5604	TRANSPORTATION DATA ANALYSIS	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

CO1	Select a suitable method for processing and presentation of transportation data.
CO2	Apply probability distributions to analyze transportation data.
CO3	Choose appropriate hypothesis testing measures.
CO4	Analyze multivariate transportation data.
CO5	Differentiate various curve fitting techniques.
CO6	Develop Time Series models.

Course Articulation Matrix:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	-	-
CO2	3	3	2	3	-	-
CO3	3	3	2	2	-	-
CO4	3	3	3	1	-	-
CO5	3	3	2	2	-	-
CO6	3	3	2	2	-	-

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Data Description and Presentation:

Type of data, a center of data, quartiles, five-number summary, the spread of data, coefficient of variation and standard deviation, a 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 actual data.

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.

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.

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.

Parameter Estimation and Curve Fitting Techniques:
Least square, generalized least squares, method of moments, maximum likelihood, algebraic and geometric curve fit, linear and non-linear curve fitting (polynomial, exponential, logarithmic, power, etc.), overfit, and under fit.

Time Series Models:
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.

Learning Resources:

Textbooks:

1. Statistical and Econometric Methods for Transportation Data Analysis, Washington, S.P., Karlaftis, M.G., Mannering, F., Anastasopoulos, P., CRC Press, 2020, Third Edition.
2. Statistical Techniques for Transportation Engineering, Molugaram, K., Rao, G.S., Shah, A., Davergave, N., Butterworth-Heinemann, 2017, First Edition.

Reference Books:

1. Multivariate Data Analysis, Joseph F.H., William C.B., Barry J.B., Anderson, R.E., Prentice Hall, 2018, Eighth Edition.
2. Probability and Statistical Inference, Robert V.H., Elliot, T., Zimmerman, D., Pearson, 2021, Tenth Edition.
3. Probability Concepts in Engineering Planning and Design, Alfredo H.S.A., Tang, W.H., Volume I & II, John Wiley & Sons, Singapore, 2007.
4. Quality Improvement through Statistical Methods, Bovas A., Springer Science & Business Media, 2012.

Online Resources:

1. http://courses.washington.edu/cee412/
2. https://ocw.mit.edu/courses/mathematics/18-05-introduction-to-probability

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CE 5605	TRAFFIC MEASUREMENTS LABORATORY	0-1-2: 2

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

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

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Volume Studies:

Direction, Duration, and Classification of Traffic Volume at Mid-Block Section and Intersections, Manual, and Mechanical Methods, Vehicle Arrival Distributions, Pedestrian and Bicycle Volume Studies.

Speed Studies:

Spot Speed Studies - Radar Speed Meters, Pedestrian and Bicycle Speed Studies.

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:

Video graphics method, Dynamic PCU estimation.

Learning Resources:

Textbooks:

1. Introduction to Traffic Engineering: Manual Field data Collect & Analysis, Currin T.R., CL Engineering, 2012, Second Edition.
2. Traffic Engineering and Transportation Planning, Kadiyali L.R., Khanna Publishers, 2011, Ninth Edition.

Reference Books:

1. Guidelines for Traffic Forecast on Highways, IRC: 108, Indian Roads Congress, New Delhi, 2015.
2. Highway Capacity Manual, Transportation Research Board, Washington, DC, 2010.
3. Indian Highway Capacity Manual (INDO-HCM), Chandra, Satish, Gangopadhyay, S, Velmurugan, S, Ravinder, Kayitha, CSIR-CRRI, 2017.
4. Principles of Highway Engineering and Traffic Analysis, Fred L. Mannering, and Scott S. Washburn, Jhon Wiley & Sons, 2013, Fifth Edition.
5. Traffic Engineering, Roger P. Roess, Elena S. Prassas, and William R. McShane, Pearson, 2019, Fifth Edition.
6. Traffic Engineering: Theory and Practice; Pignataro L.J., Prentice Hall, Inc., 1973 (Digitized in 2011)
7. Transportation Engineering, Khisty C.J., and Kent Lall, B., Prentice Hall of India Pvt. Ltd., 2012, Third Edition.

Online Resources:

1. https://jwcn-eurasipjournals.springeropen.com/articles/10.1186/s13638-019-1628-5
2. https://medium.com/goodvision/the-development-of-traffic-data-collection-cd87cc65aaab
3. https://nptel.ac.in/content/storage2/courses/105101087/downloads/Lec-32.pdf
4. https://www.crridom.gov.in/sites/default/files/Indo-HCM%20Snippets.pdf
5. https://www.dot.state.mn.us/trafficeng/publ/tem/2009/Chapter-05.pdf

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CE5606	TRANSPORTATION ANALYTICS LABORATORY	0-1-2:2

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

CO1	Identify data types and sampling methods.
CO2	Perform data analysis and interpretation using programming tools and packages
CO3	Apply statistical tests, and interpret the results.
CO4	Develop statistical and probabilistic models for transportation data.

Course Articulation Matrix:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	-	-	1	-
CO2	3	2	-	1	1	1
CO3	3	2	-	2	1	1
CO4	2	3	3	2	1	1

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Data Presentation:

Speed data analysis and graphical representation, box plots and speed profiles, parameter estimation, and histograms using MS office tools and other statistical packages SPSS and R studio.

Data Sampling and Description:

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

Data Analysis and Statistical Inference:

Speed data, vehicle arrival data, headway data, distributions, analysis, correlation, results' interpretation and multiple linear regression analysis with speed and flow data, nonlinear regression model fits, before and after significance tests on speed data, Time series analysis using transportation data. Exercises with MS Excel, SPSS, and R- studio.

Basics of Data Analysis Programming:

R tools and programming packages for data analysis, basic and advanced analysis with MATLAB, python.

Learning Resources

Textbooks:

1. Probability and Statistical Inference, Robert V.H., Elliot, T., Zimmerman, D., Pearson, 2021, Tenth Edition.
2. Quality Improvement through Statistical Methods, Bovas A., Springer Science &Business Media, 2012.
3. Software for Data Analysis: Programming with R, John C., Stanford University, Springer, 2008.

4. Transportation Statistics and Micro-simulation, Clifford S., E. S. Park, Laurence R. R., CRC Press, Taylor and Francis Group, 2011.

Reference Books:

1. Statistical and Econometric Methods for Transportation Data Analysis, Washington, S.P., Karlaftis, M.G., Mannering, F., Anastasopoulos, P., CRC Press, 2020, Third Edition.

Online Resources:

1. www.civil.iitb.ac.in/tvm/1111_nptel/531_HwayModel/plain/plain.html
2. www.cyclismo.org/tutorial/R/probability.html
3. www.endmemo.com/program/R/aov.php

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CE5611	AIRPORT INFRASTRUCTURE PLANNING AND DESIGN	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

CO1	Analyze effects of atmospheric variables on aircraft performance.
CO2	Determine the orientation of runways.
CO3	Design geometrics of the airport infrastructure.
CO4	Design thickness of the runway, taxiway, and apron.
CO5	Plan airside and landside elements of an airport.

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

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, range, 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; runway configurations, runway orientation, the wind rose, estimating runway length, sight distance and longitudinal profile, transverse gradient, airfield separation requirements, obstacle clearance requirements; taxiway and taxilane separation requirements, sight distance and longitudinal profile, exit taxiway geometry, location of exit taxiways, design of taxiway curves and intersections, end-around taxiways; aprons.

Structural Design of Airport Pavements:

FAA pavement design methods: equivalent aircraft method, cumulative damage failure method; design of flexible pavements; design of rigid pavements, joints, joint spacing, continuously reinforced concrete pavements; design of pavement overlays.

Airport Lighting, Marking, and Signage:

Requirements, 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; 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.

Airport Planning and Forecasting:
Airport planning studies: airport system plan, airport site selection, airport master plan, airport project plan; forecasting methods: time series method, market share method, econometric modeling; forecasting requirements and applications: airport system plan, airport master plan.

Learning Resources:

Textbooks:

1. Airport Engineering: Planning, Design and Development of 21st Century Airports, Ashford, N.J., Mumayiz, S.A., and Wright, P.H., Wiley India Pvt. Ltd., New Delhi, India, 2012, Fourth Edition.
2. Planning and Design of Airports, Horonjeff, R., McKelvey, F.X., Sproule, W.J., and Young, S.B., McGraw-Hill, New York, USA, 2010, Fifth Edition.

Reference Books:

1. Airport Design and Operation, Kazda, A., and Caves, R.E., Emerald Group Publishing Ltd., Bingley, UK, 2015, Third Edition.
2. Airport Planning and Design, Khanna, S.K., Arora, M.G., and Jain, S.S., Nem Chand and Bros, Roorkee, India, 2012, Sixth Edition.
3. Airport Planning and Management, Young, S.B., and Wells, A.T., McGraw-Hill Education, New York, USA, 2019, Seventh Edition.
4. Airport Systems: Planning, Design, and Management, Neufville, R.D., and Odoni, A., McGraw-Hill Education, New York, USA, 2013, Second Edition.

Online Resources:

1. https://www.aai.aero/
2. https://www.faa.gov/
3. https://www.icao.int
4. https://www.nasa.gov/topics/aeronautics/

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CE5612	ENVIRONMENTAL IMPACTS OF TRANSPORTATION	3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

CO1	Examine the effect of transportation on the environment.
CO2	Differentiate various environmental standards.
CO3	Estimate air pollution and noise pollution due to surface transportation.
CO4	Carryout an environmental impact assessment.
CO5	Apply various measures to mitigate the pollution caused by transportation.

Course Articulation Matrix:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	1	1	1	-
CO2	3	3	1	1	2	-
CO3	2	2	1	1	2	2
CO4	3	2	1	1	1	2
CO5	3	2	2	2	1	1

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Transport and Environment:

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, and Regulations:

Laws protecting the environment include environmental protection, air, noise pollution, motor vehicle acts, town and country planning, and development control regulation.

Prediction of Air and 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, an overview of methodologies, Adhoc checklist, matrix, network, overlays, benefit-cost analysis, choosing a methodology, review criteria, IRC code.

Mitigation Measures and Policies:

Cleaner fuels, vehicle technology, and replacement strategies improving fuel efficiency, encouraging non-motorized and public transport, taxation on emissions; noise barriers, land use planning, resurfacing roads with low-noise materials, managing traffic flows, advanced construction methods

Learning Resources:

Textbooks:

1. Environmental Analysis of Transportation Systems, Louis Franklin Cohen and Gary Richard McVoy, John Wiley & Sons, 1982.
2. Environmental Fate and Transport Analysis with Compartment Modeling, Keith W. Little, CRC Press, Taylor & Francis Group, 2012.
3. Environmental Impact Assessment, Canter, L.W., McGraw Hill Pub. Co., New York, 1997.
4. Methods of Environmental Impact Assessment (Natural and Built Environment Series), Peter Morris and RikiTherivel, Routledge, 2009, Third Edition.

Reference Books:

1. Best Management Practices for Environmental Issues Related to Highway and Street Maintenance: A Synthesis of Highway Practice, NCHRP Synthesis 272, National Research Council, TRB, 1999.
2. Consideration of Environmental Factors in Transportation Systems Planning, NCHRP Report 541, TRB, 2005.
3. Transport Policy and Environment, David Banister, E&FN Spain,1999
4. Guidelines for Environmental Impact Assessment for Highway Projects, IRC: 104, Indian Roads Congress, India, 1988.

Online Resources:

1. http://www.nap.edu/catalog/10354.html

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CE5613	HIGHWAY CONSTRUCTION PRACTICES	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

CO1	Develop construction procedures for subgrade, unbound, and bound granular layers.
CO2	Formulate strategies to produce optimal bituminous mixes.
CO3	Propose appropriate construction procedures for bituminous and concrete layers.
CO4	Choose appropriate pavement quality control test, and quantify construction variability

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Construction of Subgrade:

Earthwork grading; compaction and construction of embankments; types of subgrade material, factors affecting strength gain; compaction requirement for subgrade; subgrade stabilization: preparation, compaction equipment, curing and opening to construction operation; construction involving geosynthetic application in embankment slope stability and reinforcement; quality control checks for embankment and subgrade construction.

Construction of Unbound and Bound Granular Layers:

Gradation and material quality requirement for granular subbase and base layers, blending and proportioning, compaction requirements; field quality control; stabilized subbase and base layers: mix design, placing, laying and compaction requirements; crack relief and SAMI layer; geosynthetic application reinforced granular layers; construction of subsurface drainage for highways and airfield pavements.

Asphalt Plant Operations, Transport, and Delivery:

Asphalt plant functions; batch, drum, and continuous mix plants; emission controls; mix storage; asphalt mix transport: planning, haul trucks, addressing segregation, material transfer vehicle, visual inspection of the mix, and trouble shooting.

Asphalt Paving Operation:

Preparing for paving: new construction/overlay, prime coat, tack coats: recommended applications, distribution, verifying the application rates; asphalt pavers and compaction; screed operations and control; joints; compaction mechanics; cold weather paving; roller types; sequence of rolling: breakdown, intermediate and finishing; tender mixes and compaction troubleshooting; quality assurance: sampling methods for asphalt mixtures;

laboratory design verses field production; quality control tests; volumetric adjustments, density specifications.

Construction of Concrete Pavements:
Concrete production; preparation of subgrade and base; reinforcement presetting for JPCP and CRCP; establishing string line; PCC slab constructions: slip form paving, fixed form paving; curing process; quantification of curing effectiveness; quality control tests; rehabilitation of concrete pavements.

Highway Construction Management:
Pre-construction activities; construction supervision; field inspection and quality assurance.

Learning Resources

Textbooks:

1. Bituminous Road Construction in India, Kandhal, P.S., PHI Learning Pvt. Ltd, 2016, First Edition.
2. Specifications for Road and Bridge Works, Ministry of Road Transport and Highways, Indian Roads Congress, New Delhi, India, 2013, Fifth Edition.

Reference books:

1. Concrete Pavement Design, Construction and Performance, Norbert, J.D., CRC Press, 2014, Second Edition.
2. Construction of Quality Asphalt Pavements, MS-22, Asphalt Institute, 2020, Third Edition.

Online Resources:

1. https://pavementinteractive.org/reference-desk/construction/site-preparation/subgrade-preparation-for-new-pavements/
2. https://www.virginiadot.org/vtrc/main/online_reports/pdf/15-r6.pdf

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CE5614	LOW VOLUME ROAD ENGINEERING	3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

CO1	Plan low-volume road network.
CO2	Design low volume road geometrics
CO3	Identify appropriate materials and cost-effective technologies for LVRs.
CO4	Analyze and design flexible and rigid pavements for LVRs.
CO5	Select an appropriate pavement construction technique and perform quality control tests.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Low Volume Road Network Planning:

Significance, definition, characteristics of LVRs, terminology used in LVRs, PMGSY, development of LVRs in India, rural roads vision 2025, international scenario of LVRs developments, Master plan and core network concepts, network planning of LVRs and models, detailed project report preparation, environmental issues, and GIS-based rural road network planning.

Geometric Design of LVRs:

Topography and physical features, traffic, geometric design standards for LVRs with particular reference to PMGSY, Hill Road standards, design concepts and criteria, cross-sectional elements, CD works, horizontal alignment, vertical alignment, and traffic engineering requirements, international recommendations, experience, and various countries standards on LVRs geometric designs and case studies.

Marginal and New Materials:

Overview of conventional materials, waste materials, source of marginal materials, guidelines, subgrade stabilization, dealing with poor subgrades, framework for appropriate use of marginal materials, new technologies and their design aspects, Geosynthetic applications, functions, and design methods.

Pavement Design of LVRs:

LVR design principles, vehicle classifications, traffic volumes, ESALs per vehicle class, design traffic classes, pavement design methods for LVRs, empirical approaches, AUSTROADS pavement, AASHTO, US MEPDG, flexible and rigid pavement using IRC methods, and gravel road design in the Indian context.

Construction and Specifications of LVRs:
Conventional construction methods, specifications, new technologies, construction methods and benefits, case studies, low-cost construction techniques, quality control and assurance mechanism, and MoRD specifications.

Learning Resources

Textbooks:

1. Low Volume Road Engineering: Design, Construction and Maintenance, Robert A., Douglas, CRC Publishers, 2018, Ninth Edition.
2. Low-Volume Roads Engineering: Best Management Practices Field Guide, Gordon Keller and James Sherar, USDA Forest Service / USAID, 2003.
3. Guidelines for Geometric Design of Low Volume Roads, American Association of State Highway and Transport Officials, Washington, DC, 2019, Second Edition.

Reference Books:

1. An Introduction to Transportation Planning, Michael J. Bruton,Routledge Library Editions: Global Transport Planning, 2021.
2. Design Manual for Low Volume Roads, Parts A-G, Ethiopian Roads Authority.
3. Guidelines for Design and Construction of Cement Concrete Pavements for Low Volume Roads, IRC:SP62, Indian Road Congress, New Delhi, 2014, First Revision.
4. Guidelines for the Alignment Survey and Geometric Design of Hill Roads IRC:52, Indian Road Congress, New Delhi, 2019, Third Revision.
5. Guidelines for the Design and Construction of Low Volume Rural Roads Using Jute Geotextiles IRC:SP126, Indian Road Congress, New Delhi, 2019.
6. Guidelines for the Design of Flexible Pavements for Low Volume Rural Roads, Indian Road Congress, IRC:SP72, New Delhi, 2015, First Revision.
7. Guidelines for the Design of Stabilized Pavement, IRC:SP89 (P-II), Indian Road Congress, New Delhi, 2018.
8. Guidelines on Tree Plantation along Rural Roads IRC:SP103, Indian Road Congress, New Delhi, 2014.
9. Principles of Pavement Design, Yoder, E.J., and Witczak, M.W., Wiley India Pvt. Ltd., New Delhi, India, 2012, Second Edition.
10. Rural Road manual, IRC: SP20, Indian RoadsCongress, New Delhi, 2002.
11. Specifications for Rural Roads, Ministry of Rural Development, Indian Road Congress, New Delhi, 2014, Fifth revision.

Online Resources:

1. https://www.fs.fed.us/t-d/programs/forest_mgmt/projects/lowvolroads/
2. https://pdf.usaid.gov/pdf_docs/PNADB595.pdf
3. http://www.trb.org/LowVolumeRoadsConference/LVR10Literature.aspx
4. https://pmgsy.nic.in/publications
5. http://omms.nic.in/ReferenceDocs/PMGSY_Guidelines.pdf

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CE5615	OPTIMIZATION METHODS IN TRANSPORTATION	3-0-0: 3

Pre-Requisites: Nil

Course Outcomes:

At the end of the course, students will be able to

CO1	Differentiate various optimization techniques for the transport network.
CO2	Analyze characteristics of the transport network.
CO3	Formulate an LP model for the transportation problem.
CO4	Analyze multicriteria optimization for optimality.
CO5	Apply different inventory methods to optimize logistics distribution.

Course Articulation Matrix:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	-	-	-
CO2	3	2	2	2	-	-
CO3	3	3	2	2	-	1
CO4	3	2	2	2	-	-
CO5	3	3	3	3	-	-

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Basics of Optimization:

General methods for operation research models; introduction to linear and non-linear programming formulation of different models.

Network Analysis:

Network definition and network diagram representation, network attributes, minimum spanning tree, maximum flow, and minimum cost network flow problems.

Linear Programming (LP) in Transportation:

Introduction to LP and formulation of linear programming problems, graphical solution method, alternative or multiple optimal solutions, unbounded solutions, infeasible solutions, maximization – simplex algorithms.

Duality Theory:

Primal vs. dual formulations, duality theory, complementary slackness, and sensitivity analysis.

Mathematical Optimization:

Optimality criteria for the Unconstrained Problems,Optimality Criteria for the Constrained Problems, Optimality Criteria for General Optimization Problems, Postoptimality Analysis; Multicriteria Optimization, Optimization on Fuzzy Sets.

Inventory Models and Transportation Problem:

Introduction to inventory control, deterministic inventory model, EOQ model with a quantity discount, initial basic feasible solutions of balanced and unbalanced transportation/assignment problems, optimal solutions.

Learning Resources:

Textbooks:

1. Engineering Optimization Theory and Practice, Rao, S.S., Wiley Publisher, 2019, Fifth Edition.
2. Sustainable Logistics and Transportation: Optimization Models and Algorithms, Cinar, D., Gakis, K., Pardalos, P.M., Springer ,2017 ,First Edition.

Reference Books:

1. Introduction to Optimum Design, Arora, J.S., McGraw Hill International Editions, 2016, Fourth Edition
2. Mathematical Methods on Optimization in Transportation Systems, Pursula, M., Niittymäki, J., Springer; 2001, First Edition.
3. Transportation Systems Analysis: Models and Applications, Cascetta, E., Springer, 2012, Second Edition.

Online Resources:

1. https://nptel.ac.in/courses/112/106/112106134/#
2. https://sboyles.github.io/teaching/ce367

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CE5616	PAVEMENT DRAINAGE SYSTEMS	3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

CO1	Assess the impact of water on pavement performance.
CO2	Judge requirement of different cross drainage structures.
CO3	Design surface drainage system.
CO4	Evaluate the performance of pavement concerning sub-surface drainage methods.
CO5	Plan sustainable drainage systems.

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Pavement Drainage Structures:

Pavement types, relevant pavement materials, source and role of water, factors affecting the flow of water, hydraulic conductivity, estimation of surface runoff, typical drainage in pavements, detention and retention ponds, estimation of discharge of detention and retention of ponds, and impact of water on pavement distresses.

Cross Drainage Works:

The necessity of culverts, planning of culverts and effective drainage, types and size of culverts, ditches, side drains design considerations, common culverts problems, and solution, disposal of drainage water and maintenance of drainage system, stormwater harvesting methods, and benefits of groundwater recharge.

Surface Drainage:

General, the effect of standing water on pavement performance, factors affecting the surface drainage, geometric features of pavement, maintenance of side drains, medians, culverts, the hydrological requirement of roadside drains, factors affecting runoff, and design methodologies.

Subsurface Drainage:

Permeable bases stabilized and unstabilized bases, aggregate layers, geotextiles separate layers, longitudinal drains, filter design, geocomposite design and capillary barrier drain, determination of pavement permeability, and framework for drainage systems under new concrete pavements.

Sustainable Drainage:
Porous asphalt pavement design, construction, and maintenance; design of porous concrete; design of permeable interlocking concrete pavements, construction and maintenance; sustainable urban drainage systems, and applicability of specific SUDS structures.

Learning Resources:

Textbooks:

1. External Works, Roads, and Drainage: A Practical Guide, Phil Pitman, 2001.
2. Pavement Drainage; Theory and Practice, Sivakumar Babu G.L., Prithvi S. Kandhal, CRC Press, New Delhi, India, 2019.
3. Principles of Pavement Design, Yoder, E.J., and Witczak, M.W., Wiley India Pvt. Ltd., New Delhi, India, 2012, Second Edition.

Reference Books:

1. An Introduction to the Principles of Pavement Drainage, J. Paul Guyer,Independently Published, 2013.
2. Design of Road Drainage System: A Design Reference Book,S .N. Sachdeva, 2018.
3. Guidelines on Urban Drainage, IRC: SP50, Indian Roads Congress, New Delhi 2013.
4. Highway Drainage Guidelines, American Association of State Highway Official (AASTO), 2007, Fourth Edition.
5. Infrastructure Management: Integrating Design, Construction, Maintenance, Rehabilitation, and Renovation. Hudson, W. R., R. Haas, and W. Uddin., McGraw Hill. New York, 1997.
6. Subsurface Drainage Manual for Pavements in Minnesota, Caleb N. Arika, Dario J. Canelon, John L. Nieber, 2009.

Online Resources:

1. https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4986
2. https://freevideolectures.com/course/3352/geosynthetics-engineering-in-theory-and practice/21
3. https://www.youtube.com/watch?v=YQDR6fro8mM

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CE5617	REGIONAL TRANSPORTATION PLANNING	3-0-0: 3

Pre-Requisites: 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	Develop regional goods travel demand.
CO4	Plan and evaluate regional transportation networks.

Course Articulation Matrix:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
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

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.

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.

Learning Resources:

Textbooks:

1. Transportation Engineering, Khisty C.J., and Kent Lall, B., Prentice Hall of India Pvt. Ltd., 2012, Third Edition.
2. Transportation Planning Handbook, Michael D. Meyer, Institute of Transportation Engineers, John Wiley & Sons, 2016, Fourth Edition.
3. Urban and Regional Models in Geography and Planning, Wilson, A.G., Pion Press, 1974.

Reference Books:

1. Handbook of Transportation Engineering, Volume I: Systems and Operations, Meyer Kutz, Editor, McGraw Hill Education, 2011, Second Edition.
2. Handbook of Transportation Engineering, Volume II: Applications and Technologies, Meyer Kutz, Editor, McGraw Hill Education, 2011, Second Edition.
3. Metropolitan Transportation Planning, John W. Dickey, CRC Press,2018, Second Edition.
4. Transportation Engineering and Planning, Papacostas, C.S. and Prevedouros P.D., Prentice Hall of India Pvt. Ltd., 2012, Third Edition.

Online Resources:

1. https://www.nap.edu/download/22338#
2. https://www.nap.edu/download/25319
3. https://www.nap.edu/download/25332

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CE5618	ROAD ASSET MANAGEMENT	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

CO1:	Valuetheprinciplesandconceptsofassetmanagement.
CO2:	DevelopHighwayInventorysystems.
CO3:	DevelopFinancialManagementandworkforcemanagementsystems
CO4:	DevelopConstructionManagementandSafetyManagementSystems.
CO5:	DevelopBridgeManagementSystem.
CO6:	DevelopPavementManagement&HighwayMaintenanceManagementSystems.

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

HighwayAssetManagement:

Principles,typesofassetmanagementdefinition,structure,historicalbackground,elements ofhighwayassetmanagement,assetInventory,activity and cost model development,public assets versus private assets,motivationforassetmanagement,benefitsofroadasset,managementsystem, financial management systems, roads billing, roads payment andcostaccounting and tools forassetmanagement.

HighwayAssetValuationandFrameWork:

Asset Valuation approaches, guidelines, an overview of highway asset valuationprocedure,valuationprinciples,basisandrules,depreciation,highwaylighting, andhighmastlighting,landassociatedwiththehighways

ConstructionManagementSystems:

Preconstruction scheduling, utility management, ROWmanagement, useroccupancypermits,projectcontrol,agreementmonitoring,andcontractormanagement.

RoadwayOperationsManagementSystems:

Jointoperationscenter,districtoperationscenter,travelerinformationsystems.

Road AssetManagementModules:

Bridgeinventoryandrating,bridgemanagement; WorkforceManagementSystems:

Payrolldetail,personalinformation,andemployeeaccident; SafetyManagementSystems: Accidentrecords,hazardouslocation,andhighwaysafetyinformation; EquipmentManagementSystems: Equipmentmanagementinformation,fleetmanagement.

Learning Resources:

Text Books:

1. Transportation Asset Management Methodology and Application, Zongzhi Li., CRC Press, 2018, First Edition.
2. Pavement Management for Airport, Roads and Parking Lots, Shahin,M.Y., Springer, 2006, Second Edition

Reference Books:

1. Guidelines for Road Asset Management, IRC:130, Indian Roads Congress, New Delhi, India, 2020.
2. Modern Pavement Management, Haas, R., W.R. Hudson, and J.P. Zaniewski, Krieger Publishing Company, Malabar, Florida, USA, 1994.
3. PerformanceMeasuresandTargetsforTransportationAssetManagement,NCHRPReport551, TRB,Washington DC, 2006.

OnlineResources:

1. https://road-asset.piarc.org/en/management-performance-management/references
2. http://www.fhwa.dot.gov/asset/pubs/hif13047.pdf
3. http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_551.pdf
4. http://www.orams.in/

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CE 5619	TRAFFIC CONTROL AND MANAGEMENT	3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

CO1	Select traffic regulations and control strategies.
CO2	Identify and suggest speed control measures.
CO3	Design traffic control systems forroads.
CO4	Develop traffic management strategies at local and regional roads.

Course Articulation Matrix:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	-	-	1
CO2	-	2	2	3	2	1
CO3	3	3	3	3	2	1
CO4	2	3	3	3	2	1

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Traffic Control Concepts 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 control 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 system and management centers, communication and information dissemination, urban traffic management, residential neighborhood traffic management, traffic management methods, integrated traffic management system, ramp metering analysis, Local-level traffic planning and management,traffic management case studies.

Learning Resources

Textbooks:

1. Guidelines for Conducting a Traffic Signal Warrant Analysis, Hawkins, H.G., Texas Transportation Institute, 2008, Second Edition.
2. Traffic and Highway Engineering, Nicholas J. Garber, and Lester A. Hoel, Cengage Learning India, 2015, Fifth Edition.
3. Traffic Engineering, Roger P. Roess, Elena S. Prassas, and William R. McShane, Pearson, 2019, Fifth Edition.

Reference Books:

1. Demanding Traffic Control and Management in Next Generation Networks, Hamada Alshaer, Lap Lambert Academic Publishing, 2010.
2. Manual on Uniform Traffic Control Devices for Streets and Highways, USDT, Federal Highway Administration, 2009.
3. Code of Practices for Road Signs, IRC:67, Indian Roads Congress, India, 2001.

Online Resources:

1. https://www.valleytraffic.ca/news/types-of-traffic-control-equipment/
2. https://ops.fhwa.dot.gov/publications/fhwahop08024/chapter4.htm
3. https://www.fhwa.dot.gov/publications/research/operations/its/06108/02.cfm
4. www.trafficinfratech.com/area_traffic_control_system_improving_traffic_in_the_island_city/

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CE5620	TRANSPORT POLICY AND FINANCING	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

CO1	Identify issues related to transportation policies.
CO2	Examine transportation policies for the nation.
CO3	Distinguish impacts of the national transport development policies.
CO4	Appraise historical and current methods of transportation funding in India.
CO5	Evaluate the role of private parties in transportation financing.

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Introduction toTransport 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, the institutional framework for the formulation of transport policy, planning and coordination; Railways, roads, ports and airways, Transportation of critical 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.

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, an 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, congestion pricing, Fare and subsidy policies, Social costs of transportation systems.

Learning Resources:

Textbooks:

1. Transport Policy and Funding, Dai Nakagawa and RyojiMatsunaka, Elsevier, Oxford, UK, 2006.
2. Urban Transportation Economics, Kenneth A. Small and Erik T. Verhoef, Routledge, London, 2006, Second Edition.

Reference Books:

1. Highway Investment in Developing Countries, Institute of Civil Engineers, Thomas Telford Ltd., 1983.
2. National Transport Development Policy Documents, Government of India, New Delhi, 2012.
3. National Urban Transport Policy, Ministry of Urban Development, Government of India, New Delhi, 2014.
4. Transport Investment and Economic Development, David Banister and Joseph Berechman, UCL Press, London, 2000.

Online Resources:

1. https://sutp.org/publications/financing-sustainable-urban-transport-the-international-review-of-national-urban-transport-policies-and-programmes/
2. https://unece.org/fileadmin/DAM/trans/main/wp5/publications/ECE_TRANS_264_E_Web_Optimized.pdf

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CE5621	TRANSPORTATION SYSTEMS MANAGEMENT	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

CO1	Choose an appropriate TSM action for a given problematic area.
CO2	Propose a suitable method to improve transit system efficiency.
CO3	Distinguish transportation demand management strategies for their applicability.
CO4	Evaluate the functioning of UMTA.

Course Articulation Matrix:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1		1	3		3	
CO2		1	3		3	
CO3		1	3		3	
CO4		1	3			

Note: 1: Slightly; 2: Moderately; 3: Substantially

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 the car, improving traffic flow, Improving road safety, Route Planning, and Scheduling.

Transportation Demand Management:

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

Institutional Framework:

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

Learning Resources:

Textbooks:

1. Transportation Engineering, Khisty C.J., and Kent Lall, B., Prentice Hall of India Pvt. Ltd., 2012, Third Edition.
2. Transportation System Management and Operations: Action Kit – Immediate Solutions for Transportation Operational Issues, FHA, ITE, 2005.

Reference Books:

1. Traffic Engineering Hand Book, Institute of Transportation Engineers, John Wiley and Sons, 2016, Seventh Edition.
2. Transportation System Management, Special Report 172, Program Committee for the Conference on Transportation System Management, Transportation Research Board, Washington DC, 1977.
3. Transportation System Management, State of the Art, UMTA, USDOT, 1991.

Online Resources:

1. https://dot.ca.gov/programs/traffic-operations/tsmo
2. https://ops.fhwa.dot.gov/plan4ops/focus_areas/planning_prog.htm
3. https://ops.fhwa.dot.gov/publications/fhwahop14019/fhwahop14019.pdf
4. https://ops.fhwa.dot.gov/publications/fhwahop16037/index.htm
5. https://ops.fhwa.dot.gov/tsmo/

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CE5622	WATERWAY INFRASTRUCTURE PLANNING AND DESIGN	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

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

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Harbour Planning:

Types of water transportation, water transportation in India, requirements of ports and harbors, classification of harbors, selection of site and planning of harbors, location of harbor, traffic estimation, master plan, ship characteristics, harbor design, turning basin, harbor 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, the 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 the 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.

Port Demand Estimation and Management:

Forecasting demand for services of a new port, Optimal handling capacity estimation, Evaluation, and management of port projects. Long-term port planning. Modeling port demand and supply. Port traffic forecasting. Strategic Port Planning, Operational port planning, Terminal planning module.

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, the economics of inland waterways transportation, national waterways.

Learning Resources:

Textbooks:

1. A Course in Docks and Harbour Engineering, Bindra, S.P., Dhanpat Rai and Sons, 2012, Ninth Edition.
2. Harbour, Dock and Tunnel Engineering, Srinivasan R. and Rangwala S.C., Charotar Publishing House, 2018, Twenty-Ninth Edition.

Reference Books:

1. Design and Construction of Ports and Marine Structures, Alonzo Def. Quinn, McGraw – Hill Book Company, New York, 1997.
2. Dock and Harbour Engineering, Hasmukh P. Oza and Gautam H. Oza, Charotar Publishing House Pvt. Ltd, 2012.
3. Dock and Harbour Engineering, Seetharaman, S., Umesh Publications, New Delhi, India, 1999.

Online Resources:

1. http://dredge-india.nic.in/ops-main-page.html
2. https://nptel.ac.in/courses/114/106/114106025/#
3. https://www.asce.org/continuing-education/port-engineering-certificate-program/

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CE5648	SEMINAR–I	0-0-2: 1

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

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

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

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

Learning Resources:

Textbooks:

Reference Books:

1. Research Articles / Reports available on the Internet
2. Transportation Engineering Journals
3. Transportation Engineering Textbooks and Handbooks

Online Resources:

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. http://onlinepubs.trb.org/onlinepubs/circulars/ec194.pdf
4. Instructor Resources: Seminar Proposal Guidelines, SAE International; http://www.sae.org/training/seminars/instructorzone/proposalguidelines.pdf

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II Semester

CE5651	LAND USE AND TRANSPORTATION PLANNING	3-0-0: 3

Pre-Requisites: CE5601: Urban Transportation Planning

Course Outcomes:

At the end of the course, students will be able to

CO1	Differentiate various urban forms & structures.
CO2	Develop land use models.
CO3	Prepare integrated land use and transportation plans for a city.
CO4	Identify transit corridors in a city.
CO5	Apply TOD principles to enhance public transit share.

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Urban Forms and Structures:

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

Land Use Models:

Von Thunen's regional land use model, 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; Christaller central place theory- Losch's improvements; Urban regions

Land Use Transportation Models:

Classification of LUT Models, Economic Base Mechanism, Allocation Mechanism, Spatial Allocation, and Employment Relationships, Garin Lowry Models, Contribution by Putman and Wilson, Issues Related to Land use Transport - Interaction, Case Study Examples.

Transit Corridors:

Mass Transit Classifications, Transit System Characteristics, Capacity, and LOS of urban transit, transit modal options, Transit routes, and networks, Planning Concerns, and guidelines.

Transit-Oriented Development:

Introduction to Transit-based development / Transit-oriented development (TOD), TOD policy, Principles of TOD, Approach for TOD Implementation, TOD Typology, TOD Standards, Station Area Planning.

Learning Resources:

Textbooks:

1. Integrated Land Use and Transport Modelling: Decision Chains and Hierarchies, Tomas de la Barra, Cambridge University Press, 2005.
2. Land Use – Transport Interaction Models, Ruben Cordera, Angel Ibeas, Luigi dell Olio, Borja Alonso, CRC Press, 2017.
3. Transit-Oriented Development: Making it Happen, Carey Curtis, John L. Renne, and Luca Bertollnl, Routledge, 2016, First Edition.

Reference Books:

1. Land use Transportation Planning, Lecture Notes, Chari, S. R., REC, Warangal, 1988.
2. Principles of Urban Transportation System Planning, Hutchinson BG, Hutchinson, Allen,Taylor & Francis, 1986.
3. The Geography of Transport Systems, Jean-Paul Rodrigue, Dept. of Global Studies & Geography,Hofstra University, New York, USA, 2013, Third Edition, http://people.hofstra.edu/geotrans/index.html.
4. The Land Use Transport System, Blundon, W. R. and J Black, Australian Natl Univ Press, 1984, Second Edition.
5. Transportation Planning Handbook, Michael D. Meyer, Institute of Transportation Engineers, John Wiley & Sons, 2016, Fourth Edition.

Online Resources:

1. http://www.tod.org/
2. https://nptel.ac.in/courses/124/105/124105016/
3. https://www.classcentral.com/course/swayam-urban-landuse-and-transportation-planning-20017
4. https://www.vtpi.org/tdm/tdm45.htm

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CE5652	GEOMETRIC DESIGN OF TRANSPORTATION FACILITIES	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

CO1	Examine geometric characteristics and design elements of highways and streets
CO2	Analyze and design uncontrolled and signalized intersections.
CO3	Plan and Design parking facilities.
CO4	Design street lighting system for roads.

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Geometric Design of Highway Facility:

Elements of geometric design, cross-sectional elements, sight distance considerations, factor affecting geometric design, highway alignment and topography, design of horizontal alignment, design of tangents and curves, setting of layouts for simple, reverse and compound curves, design of vertical curves, tangent grade analysis, design controls and criteria for expressway, landscaping requirements, design criteria for of freeway, multilane highways and expressways, performance-based geometric design criteria, weaving segments configurations and ramp roadways, auxiliary lanes, and design practices.

Geometric Design of Intersections:

Design considerations, design elements, intersections types and their geometric suitability, alignment, and profile, functional and physical area, factors affecting geometric design, data requirement, types of turning roadway, curb radii and turning path, pedestrian considerations in design, design of channelization, median opening and islands, rotary and modern roundabout design, auxiliary lanes at intersection,ramps at intersections, design examples and practice problems.

Design of Traffic Interchanges and Pedestrian Facilities:

Classification and types, layouts of interchange, warrants, design elements, evaluation based on delay, elements of pedestrian facility design, sign of pedestrian facility at junctions, street and corner, pedestrian signals, 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.

Design of Street Lighting:

Definitions and background, pavement luminance and measurement, illumination level, Veiling Luminance, longitudinal uniformity, utilization factor, depreciation factor, maintenance factor, traffic criteria, warranting conditions, and design practices.

Design of LogisticsHubs and Terminal Facilities:
Location considerations, common standard, planning process, types and functional characteristics, modal interchange terminal design criteria and site plans, cross-section design elements, terminal concourse, multiple interchange and vertical separation, traffic circulation, design examples.

Learning Resources:

Textbooks:

1. Traffic and Highway Engineering, Nicholas J. Garber, and Lester A. Hoel, Cengage Learning India, 2015, Fifth Edition.
2. Traffic Engineering and Transportation Planning, L.R. Kadiyali, Khanna Publishers, 2011, Ninth Edition.
3. Transportation Engineering, Khisty C.J., and Kent Lall, B., Prentice Hall of India Pvt. Ltd., 2012, Third Edition.

Reference Books:

1. Guidelines for Pedestrian Facilities, IRC:103, Indian Roads Congress, India, 2012, First Revision.
2. Guidelines for the Design of At-grade Intersection in Rural and Urban Areas, IRC: SP41, Indian Roads Congress, India, 1994.
3. Guidelines for the Design of Interchange in Urban Area, IRC:92, Indian Roads Congress, India, 1985.
4. Highway Traffic Analysis and Design, Salter R.J and N.B Hounsell, Macmillan, 1996, Third Edition.
5. Principles of Highway Engineering and Traffic Analysis, Fred L. Mannering, and Scott S. Washburn, Jhon Wiley& Sons, 2013, Fifth Edition.
6. Principles of Transportation Engineering, ParthaChakroborty, and Animesh Das, PHI Learning, 2017, Second Edition.
7. Traffic Engineering Design: Principles and Practice, MikeSlinn, Paul Matthews, Peter Guest, Butterworth-Heinemann, 2005, Second Edition.
8. Traffic Engineering, Roger P. Roess, Elena S. Prassas, and William R. McShane, Pearson, 2019, Fifth Edition.
9. Traffic Engineering: Theory and Practice; Pignataro L.J., Prentice Hall, Inc., 1973 (Digitized in 2011).
10. Transport Terminals and Modal Interchanges Planning and Design, Christopher Blow, Elsevier-Architectural Press, 2005.

Online Resources:

1. https://en.wikibooks.org/wiki/Fundamentals_of_Transportation/Vertical_Curves
2. https://onlinemanuals.txdot.gov/txdotmanuals/rdw/horizontal_alignment.htm#BGBHGEGC
3. www.civil.iitb.ac.in/tvm/1111_nptel/567_Grade/plain/plain.html
4. www.slideshare.net/MichaelSantiago/road-lighting-30835916?related=2

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CE5653	PAVEMENT ANALYSIS AND DESIGN	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

CO1	Analyze stresses and strains in a flexible pavement using multi-layered elastic theory and KENLAYER.
CO2	Compute stresses and strains in a rigid pavement using Westergaard's theory and KENSLABS.
CO3	Design a flexible pavement using various methods.
CO4	Design a rigid pavement using various methods.

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Pavement Types and Materials:

Types and component parts of pavements; highway and airfield pavements; basic characteristics of materials used in pavements.

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.

Stresses in Rigid Pavements:

Westergaard's theory and assumptions; joints in rigid pavements; stresses due to curling, stresses, and deflections due to loading, frictional stresses; stresses in dowel bars and tie bars, dowel group action; stress analysis in rigid pavements using KENSLABS.

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.

Design of Flexible Pavements:

IRC method of flexible pavement design; Asphalt Institute's design methods with HMA and other base combinations; AASHTO method of flexible pavement design; design of flexible pavement shoulders; introduction to mechanistic-empirical pavement design guide.

Design of Rigid Pavements:

IRC method of plain jointed, jointed reinforced, continuously reinforced rigid pavement design; design of conventional and thin whitetopping; AASHTO method of rigid pavement design; design of rigid pavement shoulders.

Learning Resources:

Textbooks:

1. Pavement Analysis and Design, Huang, Y.H., Dorling Kindersley (India) Pvt. Ltd., New Delhi, India, 2008, Second Edition.
2. Principles of Pavement Design, Yoder, E.J., and Witczak, M.W., Wiley India Pvt. Ltd., New Delhi, India, 2012, Second Edition.

Reference Books:

1. Guidelines for Conventional and Thin Whitetopping, IRC: SP76, Indian Roads Congress, New Delhi, India, 2015, First Revision.
2. Guidelines for Design and Construction of Continuously Reinforced Concrete Pavement, IRC: 118, Indian Roads Congress, New Delhi, India, 2015.
3. Guidelines for the Design of Flexible Pavements, IRC: 37, Indian Roads Congress, New Delhi, India, 2018, Fourth Revision.
4. Guidelines for the Design of Plain Jointed Rigid Pavements for Highways, IRC: 58, Indian Roads Congress, New Delhi, India, 2015, Fourth Revision.
5. Thickness Design – Asphalt Pavements for Highways and Streets, Manual Series No. 1, Asphalt Institute, Kentucky, USA, 1999, Ninth Edition.

Online Resources:

1. http://onlinepubs.trb.org/onlinepubs/archive/mepdg/guide.htm
2. http://www.trb.org/Pavements/TRBPublications.aspx
3. https://link.springer.com/article/10.1007/BF03325749
4. https://pavementinteractive.org/

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CE5654	ROAD SAFETY ENGINEERING	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

CO1	Analyze the effect of user, roadway,and environment characteristicson traffic
CO2	Plan and design of road safety improvement programs.
CO3	Evolve safety measures using accident data.
CO4	Conduct road safety audit.
CO5	Interpret accident data using statistical analysis.

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Basics of RoadSafety:

Road accidents, Trends, Global and Indian level, Crash Causation, Collision diagrams; Highway safety; Human factors and road user limitations; Speed and its effect on road safety; Vehicle factors; Highway safety in India.

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, Hot spot analysis, Case Studies.

Road Safety Management System:

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

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, 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; Design of Forgiving roads and self-explaining roads, Effective Road Signs and Street Lighting, Safety in urban areas; Public transport and safety; Road safety policy-making, Stakeholders involvement; Road safety law.

Learning Resources:

Textbooks:

1. Observational Before-After Studies in Road Safety, Ezra Hauer, Pergamon Press, 1997 (Reprinted 2002).
2. Traffic Safety, Leonard Evans, Science Serving Society, 2006.
3. Transport Planning and Traffic Safety: Making Cities, Roads, and Vehicles Safer, Geetam Tiwari, and Dinesh Mohan, CRC Press, 2016, First Edition.

Reference Books:

1. The Handbook of Road Safety Measures, Rune Elvik, TrulsVaa, Alena Hoye, Michael Sorensen, Emerald Group Publishing, 2009, Second Edition.
2. The Traffic Safety Toolbox: A Primer on Traffic Safety, ITE, 1999.
3. Towards Safe Roads in Developing countries, TRL–ODA, 2004.
4. Traffic Accident Reconstruction, Lynn B. Fricke, Northwestern University Center for Public Safety, 1990.
5. Traffic Collision Investigation, Kenneth S Baker, J Stannard Baker, Northwestern University Center for Public Safety, 2001.
6. Traffic Control and Road Accident Prevention, Popkess C.A, Chapman and Hall, 1997.

Online Resources:

1. http://tripp.iitd.ernet.in/publication/report
2. https://atpio.org/webinar-on-addressing-road-safety-worldwide-vulnerable-road-users-human-factors-rs-in-lmic/
3. https://ebrdelearning.com/course
4. https://morth.nic.in/reports-working-group-4-es-road-safety-0
5. https://vimeo.com/294277710
6. https://www.ptvgroup.com/en/solutions/products/ptv-visum/ptv-visum-safety/
7. https://www.who.int/data/gho/data/themes/road-safety
8. https://www.who.int/teams/social-determinants-of-health/safety-and-mobility/decade-of-action-for-road-safety-2021-2030

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CE5655	PAVEMENT MATERIALS AND EVALUATION LABORATORY	0-1-2: 2

Pre-Requisites: Characterization of Pavement Materials

Course Outcomes:

At the end of the course, students will be able to

CO1	Characterize the pavement materials.
CO2	Perform quality control tests on pavement and pavement materials.
CO3	Evaluate functional response characteristics of in-service pavements
CO4	Estimate structural response characteristics of in-service pavements.

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Tests on Soils:

Liquid limit, plastic limit, soil classification (dry and wet), maximum dry density and moisture content, and CBR test.

Tests on Aggregate:

Aggregate gradation, shape tests, specific gravity, water absorption, Los Angeles abrasion value, aggregate impact value, and soundness test.

Tests on Bitumen:

Penetration, absolute and kinematic viscosity, flash and fire point, ductility, elastic recovery, softening point, specific gravity, apparent viscosity of bitumen using a rotational viscometer, and short-term aging of bitumen.

Field Tests:

Field density using sand replacement method, rapid moisture meter.

Tests on Bituminous Mixes:

Stripping value of aggregate, determination of Gmm of given bituminous mixtures using CoreLok system, Marshall mix design.

Bitumen content and gradation using centrifuge extractor and NCAT ignition oven; determination of tensile strength ratio for a given bitumen mix.

Roller compaction and permanent deformation using wheel tracking equipment.

Field Evaluation:

Pavement condition rating, unevenness using MERLIN, Dynamic Cone Penetrometer and Clegg Impact Test, Overlay design using Benkelman Beam Deflection;FWD.

Learning Resources:

Textbooks:

1. Highway Materials and Pavement Testing, S.K. Khanna, C.E.G. Justo, and A. Veeraragavan, Nem Chand and Bros, Roorkee, India, 2014, Fifth Edition.
2. Highway Material Testing and Quality Control, G.V Rao, I.K International Publishing House Pvt. Ltd., New Delhi, India, 2015.

Reference Books:

1. Laboratory Testing Manual, Central Materials Laboratory, Ministry of Works, the United Republic of Tanzania, 2000.
2. Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique, IRC:81, Indian Road Congress, New Delhi, 2012.
3. Guidelines for Structural Evaluation and Strengthening of Flexible Road Pavements Using Falling Weight Deflectometer (FWD) Technique,IRC:115, Indian Road Congress, New Delhi, 2014.
4. Guidelines on Measuring Road Roughness and Norms,IRC:SP16,Indian Road Congress, New Delhi, 2019, Second Revision.
5. Laboratory Manual in Highway Engineering, Ajay K. Duggal, New Age International Private Limited,2017, SecondEdition.
6. Manual for Quality Control in Road and Bridge works,IRC:SP112, Indian Road Congress, New Delhi, 2017.
7. Pavement Analysis and Design, Huang, Y.H., Dorling Kindersley (India) Pvt. Ltd., New Delhi, India, 2008, Second Edition.
8. Relevant IS and ASTM Codes.

Online Resources:

1. https://www.youtube.com/watch?v=UWmAabRxR6w
2. https://nptel.ac.in/courses/105/105/105105107
3. https://www.youtube.com/watch?v=C10dkIH12W0

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CE5656	TRANSPORTATION SOFTWARE LABORATORY	0-1-2:2

Pre-Requisites:

1. CE5601: Urban Transportation Planning
2. CE5602: Traffic Analysis
3. CE5606: Transportation Data Analytics Laboratory
4. CE5653: Pavement Analysis and Design

Course Outcomes:

At the end of the course, students will be able to

CO1	Estimate Travel Demand using transportation planning packages.
CO2	Design isolated and coordinated traffic signals using micro-simulation tools.
CO3	Demonstrate Ken layer and Ken slab for pavement design.
CO4	Simulate traffic facilities using VISSIM.

Course Articulation Matrix:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	--	2	--	2
CO2	3	3	--	2	--	2
CO3	3	3	--	2	--	2
CO4	3	3	--	2	--	2

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Transportation Planning Software:

Basic understanding and knowledge of software related to transportation planning and logistic, Software used; Cube, VISUM, Logistic models, Sidra trip, VISTRO, TRANSIMS.

Traffic Engineering Software:

Concepts and theory on software development, Basic and advanced practices on microscopic and macroscopic traffic flow modeling software. It includes signal time optimizations and pedestrian flow modeling. Software used; VISSIM, VISWALK, Junction 10, Sidra, Pramaics, Amisun, Sumo, TRANSYT.

Highway and Pavement Engineering Software:

The software commonly used for highway geometric design and pavement analysis is included in this module. Software used: Mx road, open road, HDM-4, Ken-layer, Ken-slab.

Learning Resources:

Textbooks:

1. User manuals of each software

Reference Books:

1. Principles of Highway Engineering and Traffic Analysis, Fred L. Mannering, and Scott S. Washburn, Jhon Wiley & Sons, 2013, Fifth Edition.

2. Transport Planning and Traffic Engineering, Coleman A. O 'Flaherty, Butterworth-Heinemann, 2009.

Online Resources:

1. https://company.ptvgroup.com/en/expertise/microsimulation
2. https://trlsoftware.com/products/junction-signal-design/
3. https://trlsoftware.com/products/traffic-control/

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CE5661	ADVANCED TRAVEL DEMAND MODELLING	3-0-0: 3

Pre-Requisites: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	Assess travel demand using Stated Preference data.
CO4	Estimate Travel Demand using activity-based analysis.
CO5	Test model aggregation and transferability.

Course Articulation Matrix:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
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

Note: 1: Slightly; 2: Moderately; 3: Substantially

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

QualitativeVariables:

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.

Learning Resources:

Textbooks:

1. Modelling Transport, Ortuzar J de D and LG Willumsen; New York: John Wiley and Sons, 2011, Fourth Edition.
2. Urban Travel Demand Modelling: From Individual Choices to general Equilibrium, Oppenheim, N., John Wiley and Sons, Inc., 1995 (Digitized 29 June 2011).

Reference Books:

1. Activity-Based Travel Demand Models: A Primer, Joe Castiglione, Mark Bradley, and John Gliebe, TRB, Washington, DC, 2015
2. Discrete Choice Analysis: Theory and Application to Travel Demand, Moshe Ben-Akiva, Steven R. Lerman, MIT Press, 2018
3. Discrete Choice Modelling and Air Travel Demand: Theory and Applications, Laurie A. Garrow, Routledge, 2010
4. Optimization in Location and Transport Analysis, Alan Geoffrey Wilson, John Wiley & Sons, 1981 (Digitized: 31 March 2011).
5. Progress in Activity-Based Analysis, Harry Timmermans, Elsevier Science, 2005.
6. Time use Analysis, Special Issue, Transportation, 26, Kluwer Academic Publishers, 1999.

Online Resources:

1. http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_C46.pdf
2. https://www.nap.edu/download/13678

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CE5662	BIG DATA ANALYTICS IN TRANSPORTATION	3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

CO1	Formulate an effective approach to capture transportation data.
CO2	Apply predictive and prescriptive analytics to transportation problems.
CO3	Examine the relevance of machine learning to transportation system operations.
CO4	Identify appropriate algorithms for data mining and machine learning.
CO5	Apply Big Data concepts in transportation engineering.

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Basics of Big Data:

Introduction to Big Data, Exponential growth and the new availability of data, Structured and unstructured data, Rapid acceleration in many dimensions (volume, velocity, variety, variability, and complexity), 3 V's of the Gartner's definition of big data, i.e., high volume, high velocity or high variety, veracity, value.

Data Exploration and Data Visualization:

Data types: Sensor data, audio, video data, combinations of data, Predicting and Forecasting methods, Sampling errors, Smart data management: Manage and understand the data. Anonymization, Aggregation, Interpretation, Processing, Modeling, Time Patterns, Spatial Signature, Flows Patterns, Open Data concepts.

Data Mining Strategies:

Operations in Data Mining, Descriptive analytics, Prepares and analyze historical data, Identify patterns from samples for reporting of trends, Predictive analytics, Predicts future probabilities and trends, Relationships in data that may not be readily apparent with descriptive analysis, Prescriptive analytics, Evolution of Computer Processors and storage methods.

AI and Machine Learning:

AI for Big data analysis, Hadoop Concepts, and application for Big Data, Scaling Out, Supported Vector Machine, Tree-based Methods, Clustering, Text Mining, Topic Modeling Sentiment Analysis, Machine learning, and TSMO, Historical performance reporting, Mechanisms related to transportation demand and supply, Future Transportation Demand and Supply, Automated transportation back office, Machine learning, and big data, Neural Network Deep Learning, Network Analysis.

Big Data Applications in Transportation:
Exploring Regularity and Structure in Travel Behavior Using Smart Card Data Estimating a Rail Passenger Trip Origin-Destination Matrix Using Automatic Data Collection Systems, Automatic Data for Applied Railway Management: A Case Study on the London Overground, Trip Detection Using Sparse CDR Data based on Supervised Statistical Learning, Demand Management in Public Transit: Design and Evaluate Crowding Reduction Strategies in Hong Kong.

Learning Resources:

Textbooks:

1. Big Data Analytics in Traffic and Transportation Engineering: Emerging Research and Opportunities, Sara Moridpour, IGI Global, 2019, First Edition.
2. Transportation Analytics in the Era of Big Data, Ukkusuri, Satish V., Yang, Chao, Springer, 2019, First Edition.

Reference Books:

1. Big Data Analytics for Connected Vehicles and Smart Cities, Bob Mcqueen, Artech House, 2017, First Edition.
2. Big Data Science and Analytics: A Hands-On Approach, ArshdeepBahga, Vijay Madisetti, VPT, 2016, First Edition.
3. Data Analytics for Intelligent Transportation Systems, Mashrur Chowdhury, Amy Apon, and Kakan Dey, Elsevier, 2017, First Edition.
4. Machine Learning: A Probabilistic Perspective, Murphy K., MIT Press, 2012.

Online Resources:

1. https://pdxscholar.library.pdx.edu/cgi/viewcontent.cgi?article=1156&context=trec_reports
2. https://policy.transportation.org/wp-content/uploads/sites/35/2018/09/Street-Light-Data-Big-Data-Analytics-for-Active-Transportation-and-Multimodal-Planning.pdf
3. https://policy.transportation.org/wp-content/uploads/sites/35/2018/09/Street-Light-Data-Big-Data-Analytics-for-Active-Transportation-and-Multimodal-Planning.pdf
4. https://static1.squarespace.com/static/59f9cdc2692ebebde4c43010/t/5b49c213352f534ffb42e3d8/1531560480749/20180711_D1.1_Understanding+and+mapping+big+data+in+transport+sector_LeMO.pdf
5. https://transportationops.org/event/big-data-analytics-transportation-systems-management-and-operations
6. https://www.e-education.psu.edu/geog855/node/695
7. https://www.hcltech.com/blogs/future-transportation-real-time-analytics
8. https://www.ptvgroup.com/en/solutions/products/ptv-maps-data/data-analytics/
9. https://www.springer.com/journal/42421
10. https://www.supplychain247.com/article/3_ways_data_analytics_enables_smarter_transportation_management

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CE5663	GIS FOR TRANSPORTATION SYSTEMS	3-0-0: 3

Pre-Requisites: 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	Analyze Transport Networks.
CO4	Model spatial and transportation facilities in GIS.
CO5	Integrate ITS with GIS.
CO6	Map transportation-related environmental pollutants, accidents in the GIS platform.

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

GIS – Transportation Data Models:

Data Domains and Data Modelling in GIST; 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 Sourcesand Integration:

Basic Mapping Concepts; Transportation Data Capture and Data Products; Transportation Data Integration; Spatial Data Quality; Spatial and Network aggregation.

Shortest Pathsand Routing:

Fundamental Network Properties; Fundamental Properties of Algorithms; Shortest Path Algorithms; Routing Vehicles within Networks.

Network Flowsand 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 Analysisand Modeling:

GIS and spatial analysis; Urban sprawl; GIS Analytical functions; Coupling Transportation Analysis and Modelling with GIS; Customizing GIS; Supporting Advanced Transportation Analysis in GIS.

Transportation Planning:

Transportation Analysis Zone Design; Travel demand Analysis; Landuse – Transportation Modelling; Route Planning; Decision support for Transportation Planning.

Intelligent Transportation Systems:
ITS Applications; ITS Architectures and Geographic Information; Integrating GIS and ITS.

Transportation, Environment,and Hazards:
Mapping sensitive Environmental features; GIS and Transportation related Air Quality; Accidents and Safety Analysis; Transportation of hazardous materials; GIS in Asset Management

Learning Resources:

Textbooks:

1. Geographic Information Systems for Transportation (GIST): Principles and Applications, Miller HJ and Shaw SL, Oxford University Press, 2001
2. Geographical Information Systems for Urban and Regional Planning, Henk J. Scholten and John Stillwell, Springer, 2010.

Reference Books:

1. Adaptation of Geographic Information Systems for Transportation, NCHRP Report 359, TRB, Washington, DC, 1993.
2. Concepts and Techniques of Geographic Information Systems,C.P.Lo, Albert K. W.Yeung, Pearson, 2016, Second Edition.
3. Geographic Information Systems Applications in Transit: A Synthesis of Transit Practice, TCRP Synthesis 55, TRB, 2004.
4. GIS in Transportation, Thill JC, Transportation Research Part C, 2000.
5. GIS Support Transportation System Planning, Simlowitz H.J., International GIS Sources Book
6. 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, Alan Paul Vonderohe, Alan Travis, and Robert Smith, TRB, 1991.
7. Use of Advanced Geospatial Data, Tools, Technologies, and Information in Department of Transportation Projects: A Synthesis of Highway Practice, NCHRP Synthesis 446, TRB 2013.

Online Resources:

1. https://transportgeography.org/contents/methods/geographic-information-systems-transportation/
2. https://www.esri.com/library/bestpractices/urban-regional-planning.pdf48
3. https://www.gis.fhwa.dot.gov/documents/gis_assetmgmt.pdf

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CE5664	INTELLIGENT TRANSPORTATION SYSTEMS	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

CO1	Identify and differentiate ITS user services and their components.
CO2	Propose appropriate ITS technology to solve real-life traffic problems.
CO3	Estimate traffic congestion by the acquisition of big data using advanced devices.
CO4	Design and implement suitable ITS and services for effective transportation.
CO5	Select suitable standards for effective implementation of ITS.

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

ITS History and Applications:

ITS Background and Telemetric systems: Definitions, features, and objectives of ITS, History of ITS and its development worldwide, 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, traveler information, COV, 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, Traffic Command and Control Center design and implementation, System Integrator and Smart Transportation Management, case studies.

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

Learning Resources:

Textbooks:

1. Fundamentals of Intelligent Transportation Systems Planning, M.A. Chowdhury and A. Sadek, Artech House, 2010, First Edition.
2. Intelligent Transport Systems, Sarkar, Pradip Kumar, and Amit Kumar Jain, PHI Learning, 2018, First Edition.
3. Perspectives on Intelligent Transportation Systems (ITS), J.M. Sussman, Springer, 2005, First Edition.

Reference Books:

1. Economic Impacts of Intelligent Transportation Systems: Innovations and Case Studies, Bekiaris and Y.J. Nakanishi, Elsevier/JAI, 2004.
2. IET Intelligent Transport Systems and 15th International IEEE Conference on Intelligent Transportation Systems (ITSC), September 2012.
3. Intelligent Transport Systems Standards, Bob Williams, Artech House Publishers, 2008.
4. Intelligent Transport Systems: Cases and Policies, RogerStough, Edward Elgar, 2001.
5. Intelligent Vehicle Technologies – Theory and Applications, L. Vlacic, M. Parent, F. Harashima, Butterworth-Heinemann, 2010.
6. The Implication of Intelligent Transport Systems for Road Safety, Austroads Incorporated, 1999.

Online Resources:

1. http://digital-library.theiet.org/content/journals/iet-its
2. http://digital-library.theiet.org/content/journals/iet-its
3. http://www.tandfonline.com/toc/gits20/current
4. https://www.its.dot.gov/history/pdf/HistoryofITS_book.pdf
5. https://www.its.dot.gov/research_areas/data_access.htm
6. https://www.its.dot.gov/research_areas/emerging_tech.htm
7. https://www.sciencedirect.com/topics/engineering/intelligent-transportation-system
8. https://www.wevolver.com/article/a.review.of.autonomous.vehicle.safety.and.regulations

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CE5665	LOGISTICS AND FREIGHT TRANSPORTATION SYSTEMS	3-0-0: 3

Pre-Requisites: CE5651 Urban Transportation Planning

Course Outcomes:

At the end of the course, students will be able to

CO1	Distinguish characteristics of passenger and freight demand.
CO2	Develop freight demand models.
CO3	Analyze freight moment based on mode and route.
CO4	Deploy ITS technologies for an efficient flow of freight.
CO5	Explore logistics and planning strategies.

Course Articulation Matrix:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	-	-	-
CO2	3	2	2	-	-	-
CO3	3	2	2	3	-	-
CO4	2	2	2	1	-	-
CO5	3	2	1	1	-	-

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Characteristics of Freight Transport:

Freight Characteristics, Factors influencing Freight Travel, operators, problems in freight transportation, regional vs. urban goods travel, intermodal freight travel issues, the difference between passenger and freight demand models.

Freight Demand Estimation:

Operations, Planning - purpose, process, Data, Freight Agents, costs, Planning Models and Methods-freight demand estimation and forecasting at the regional and urban level, Freight Generation and Freight Trip Generation, Trend and time series models, freight trip rate models, IO models.

Freight Transport Planning and Operations:

Freight supply – capacity issues; freight productivity and performance; distribution of freight flows; production/consumption to origin/destination, competing modes for specific commodity choice, route planning, scheduling, collection storage, distribution centers, regulation, and enforcement of freight transport.

Urban Freight Model Forms:

Sources of data availability: proprietary, semi-public, and public, data granularity, connecting various data sources to freight demand models, freight models in practice and decision making, sustainable solutions for urban freight transport.

Inter-Intra Freight Transport Models:
Modeling local freight, GPS-based freight data, urban freight last-mile delivery, ITS applications for urban freight data.

Logistics and Planning Strategies:
Context of Logistics-Activities of Logistics, Aims of Logistics, Importance of Logistics, Current Trends in Logistics; Logistics Strategy-Strategic Decisions, Logistics Strategy, Designing a Logistics Strategy; Locating Facilities-Importance of Location, Choosing the Geographic Region, Infinite Set Approaches, Feasible Set Approaches, Network Models, Location Planning; Planning Resources-Types of Planning, Capacity Planning, Adjusting Capacity, Tactical Planning, Schedules.

Learning Resources:

Textbooks:

1. Freight Transport Modelling, Ben-Akiva, M., Meersman, H., de Voorde, E.V., Emerald Group Publishing, 2013.
2. Modelling Freight Transport, Tavasszy, L., Jong, G.D., Elsevier Publishers, 2013, First Edition.

Reference Books:

1. City Logistics: Modelling, planning and evaluation, Taniguchi, E., Routledge, 2017, First Edition.
2. Freight and Logistics Transport Modelling and Planning, Al-Azzawi, M., LAP Lambert Academic Publishing, 2012,
3. Handbook of Transportation Engineering, Volume I: Systems and Operations, Meyer Kutz, Editor, McGraw Hill Education, 2011, Second Edition.
4. Handbook of Transportation Engineering, Volume II: Applications and Technologies, Meyer Kutz, Editor, McGraw Hill Education, 2011, Second Edition.
5. Intermodal Freight Transport, Lowe, D., Elsevier Butterworth Heinemann Publishers, 2006, First Edition.

Online Resources:

1. https://ocw.mit.edu › courses › lecture-notes ›Freight demand - MIT OpenCourseWare
2. https://ocw.tudelft.nl/wp-content/uploads/transportation-lecturenotes.pdf

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CE5666	PAVEMENT EVALUATION AND REHABILITATION	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

CO1	Evaluate pavement based on surface conditions.
CO2	Assess structural strength of pavements.
CO3	Select appropriate pavement rehabilitation options.
CO4	Prioritize pavement maintenance strategies.

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Functional Evaluation of Pavements:

Importance of pavement evaluation, functional condition evaluation techniques, network, project level, roughness measurement methods, Identification of uniform sections, serviceability concepts, visual and rating procedures, data collection technologies, pavement deterioration, factors affecting pavement deterioration, modeling, and comparison of different deterioration models.

Structural Evaluation of Pavements:

Structural condition evaluation, static, semi-static, moving deflection measuring devices, rebound deflection, deflection bowl measurement and analysis, AASHTO AND IRC overlay design method, back-calculation of layer moduli, ground-penetrating radar evaluation of pavement safety: skid resistance, mobile devices measuring skid resistance and hydroplaning.

Pavement Rehabilitation:

Introduction, benefits of recycling, methods, recycling strategies, cold milling, ripping, crushing, recycling batch plant, drum mix plant, mix design, ho tin place recycling techniques, cold in-place recycling, full-depth reclamation, and current practices for improving riding quality.

Pavement Maintenance:

Surface distresses, types, causes and redial measures, types of maintenance, classification of maintenance activities, pavement maintenance norms maintenance, development of decision tree, decision matrix, selection of treatment strategies, local, global maintenance and rehabilitation strategies, HDM-4 applications, and life cycle cost analysis.

Learning Resources:

Textbooks:

1. Bituminous Road Construction in India, Kandhal, P.S., PHI Learning Pvt. Ltd, 2016, First Edition.
2. Pavement Management for Airport, Roads and Parking Lots, Shahin, M.Y., Springer, 2006, Second Edition
3. The Design and Performance of Road Pavements, Croney, D., and P. Croney., McGraw-Hill Book Company, London, UK, 1991.

Reference Books:

1. Modern Pavement Management, Haas, R., W.R. Hudson, and J.P. Zaniewski, Krieger Publishing Company, Malabar, Florida, USA, 1994.
2. Pavement Analysis and Design., Huang, Y.H., Dorling Kindersley (India) Pvt. Ltd., New Delhi, India, 2008, Second Edition.
3. Pavement Design and Materials, Papagiannakis, A.T., Masad, E.A., Wiley, 2008, First Edition.
4. Pavement Engineering – Principles and Practice, Mallick, R.B. and T. El-Korchi, CRC Press, Taylor and Francis Group, Florida, USA, 2009.
5. Relevant Indian Road Congress codes, Bureau of Indian Standards, and International standards such as ASTM and AASHTO.
6. Specifications for Road and Bridge Works, Ministry of Road Transport and Highways, Indian Roads Congress, New Delhi, India, 2013, Fifth Edition.

Online Resources:

1. https://www.pavementinteractive.org/
2. https://www.appliedpavement.com/pavement-evaluation-and-design.html
3. https://freevideolectures.com/course/91/introduction-to-transportation-engineering/40

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CE5667	PUBLIC TRANSPORTATION SYSTEMS	3-0-0: 3

Pre-Requisites:CE5601: Urban Transportation Planning

Course Outcomes:

At the end of the course, students will be able to

CO1	Differentiate different transit systems
CO2	Estimate transit demand
CO3	Analyze bus route network and prepare bus schedules
CO4	Identify mass transit corridors
CO5	Evaluate transit performance
CO6	Plan and Design transit terminals

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Transit Systems:

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.

Bus 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 - Signal System - Aesthetics and Noise Consideration - Cost of Construction - Station Arrangements - Platform Capacity - Fare Collection, Transit Marketing.

Public 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:
Transit Terminal Planning and Design – Performance Evaluation – Efficiency, Capacity, Productivity and Utilization – Performance Evaluation Techniques and Application – System Network Performance –

Learning Resources:

Textbooks:

1. Public Transport: Its Planning, Management, and Operation, Peter R. White, London New York, 2008, Fifth Edition.
2. Urban Transit: Operations, Planning, and Economics, Vukan R. Vuchic, Wiley, 2017.

Reference Books:

1. Bus Transport: Economics, Policy, and Planning, David A. Hensher, Research in Transportation Economics Volume 18. Elsevier Publications, 2007.
2. Public Transport Planning and Management in Developing Countries, Ashish Verma, Ramanayya, T.V., CRC Press, 2014.
3. Public Transportation Systems: Principles of System Design, Operations Planning and Real-time Control, Carlos F Daganzo, Yanfeng Ouyang, World Scientific Publishing Company, 2019.
4. Public Transportation: Planning, Operation and Management, George E. Gray and Lester A. Hoel, Prentice Hall; 1992, Second Edition.
5. Urban Mass Transportation Planning, Alan Black, McGraw-Hill International, 1995.
6. Urban Public Transport Today, Simpson, Barry J., Taylor & Francis Routledge Publisher, 2003.
7. Urban Transport for Growing Cities: High Capacity Bus System, Tiwari G., MacMillan India Ltd., 2002.
8. Urban Transportation: Planning, Operation and Management, Jihnson Victor D., Ponnuswamy, S., Tata McGraw-Hill Education, 2012.

Online Resources:

1. https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-258j-public-transportation-systems-spring-2017/index.htm?utm_source=OCWCourseList&utm_medium=CarouselSm&utm_campaign=FeaturedCourse
2. https://www.apta.com/
3. https://www.uitp.org/

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CE5668	RAILWAY INFRASTRUCTURE PLANNING AND DESIGN	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

CO1	Plan the railway network.
CO2	Determine factors governing the design of railway infrastructure.
CO3	Design the railway track system and identify a suitable signal system.
CO4	Develop maintenance strategies for the railway track system.
CO5	Recommend suitable measures for the safety of the railway network.
CO6	Assess requirements of high-speed railway track.

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Planning of Railway Lines:

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.

Components of Railway Track and Rolling Stock:

Permanent way, forces acting, 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.

Railway Track Geometric Design:

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

Track Construction and Maintenance:

Track laying, inspection and maintenance, maintenance tools, maintenance of rail surface, track drainage, track tolerances, mechanized method, ballast confinement and directed track maintenance, bridge maintenance, renewal, classification of renewal works, 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, derailments, 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, slip sidings, foot over bridges, subways, cranes, weighbridge, loading gauge, end loading ramps, locomotive sheds, triangles, traverser, carriage washing platforms, buffer stop, scotch block, derailing switch, sand hump, fouling mark.

High-Speed Railways:
Modernization of railways, the effect of high-speed track, vehicle performance on the track, railway track design for high speeds, dedicated freight corridors, high-speed ground transportation system, ballastless track, elevated railways, underground and tube railways.

Learning Resources:

Textbooks:

1. Railway Engineering, Chandra, S., and Agarwal, M.M., Oxford University Press, Noida, India, 2013, Second Edition.
2. Railway Track Engineering, Mundrey, J.S., Tata McGraw-Hill Education Private Limited, New Delhi, India, 2017, Fifth Edition.

Reference Books:

1. A Textbook of Railway Engineering, Saxena, S.C., and Arora, S.P., Dhanpat Rai Publications, New Delhi, India, 2017, Eighth Edition.
2. Indian Railway Track, Agarwal, M.M., Prabha & Co., New Delhi, India, 2018, Twentieth Edition.
3. Railway Engineering, Gupta, B.L., and Gupta, A., Standard Publishers Distributors, New Delhi, India, 2012, Third Edition.
4. Railway Engineering, Rangwala, S.C., Charotar Publishing House Pvt. Ltd., Anand, India, 2017, Twenty Seventh Edition.

Online Resources:

1. https://rdso.indianrailways.gov.in
2. https://www.iricen.gov.in
3. https://uic.org/

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CE5669	SUSTAINABLE TRANSPORTATION	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

CO1	Identify a sustainable transportation system.
CO2	Consider sustainability in providing mode choices for the public.
CO3	Develop and plan pedestrian facilities for sustainable transportation.
CO4	Plan for bicycle facilities.
CO5	Suggest policies that improve the sustainability of transportation.

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Problem of Sustainability in Transport:

Energy use in the transport sector; Transport and climate change; Greenhouse gas emissions, urban air quality, Congestion, and sustainability, Sustainable Development Goals.

Planning for Sustainability:

Urban form, Indicator based planning, land use transport 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: total 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

Learning Resources:

Textbooks:

1. An Introduction to Sustainable Transportation: Policy, Planning and Implementation, Preston L. Schiller, Eric C. Brunn, and Jeffrey R. Kenworthy, Routledge, 2010.
2. Sustainable Transport: Planning for Walking and Cycling in urban environments, Rodney Tolley, Editor, CRC Press, 2003.
3. Sustainable Transport: Problems and Solutions, Black, W.R., Guilford Press, New York, 2010.

Reference Books:

1. Accessible Cities and Regions: A Framework for Sustainable Transport and Urbanism in the 21st Century, Cervero, R., Center for Future Urban Transport, Institute of Transportation Studies, University of California, Berkeley, 2005.
2. Sustainable Transport: Definitions and Responses, In Transportation Research Board, Integrating Sustainability into the Transportation Planning Process, Conference Proceedings 37, Black, W. R., National Research Council,Washington, DC, 2005.
3. Transportation Technologies for Sustainability, Mehrdad Ehsani, Fei-Yue Wang and Gary L. Brosch (Eds.), Springer-Verlag, New York, 2013.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc21_ce74/preview
2. https://www.cutr.usf.edu/workforce/education/sustainable-transportation-course/

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CE5670	TRAFFIC FLOW MODELLING AND SIMULATION	3-0-0:3

Pre-Requisites: CE5602 Traffic Analysis and Design

Course Outcomes:

At the end of the course, students will be able to

CO1	Distinguish methods of traffic flow modeling.
CO2	Explore pedestrian stream models.
CO3	Analyze shock waves and queuing patterns.
CO4	Develop and validate traffic simulationmodels.

Course Articulation Matrix:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	-	1
CO2	3	3	3	3	-	1
CO3	3	3	3	3	-	2
CO4	3	3	3	3	-	2

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Traffic Flow Modeling:

Basic concepts, time-dependent and independent models, advanced macroscopic models,microscopic models modeling approach, lane changing models,N-T curves, gap acceptance models,inhomogeneous highway, moving bottlenecks, LWR models and its extension, car-following models, traffic based probabilistic and stochastic models

Pedestrian Flow Modeling:

Pedestrian behavior-based modeling, pedestrian behavioral models, pedestrian interactions models, microscopic and macroscopic models, pedestrian simulation concepts, pedestrian stream model examples.

Shockwave Analysis:

Shock wave theory, shockwaves propagation and speeds, shock waves at various facilities, signalized intersections, shockwaves due to specialcauses, shockwave modeling, case studies, and examples.

Queuing Analysis:

Queuing theory, queue discipline and patterns, deterministic analysis, stochastic analysis, single-channel,multiple channels, moving queue at bottlenecks and junctions, queuing examples for practices.

Simulation Methodologies:

Fundamentals and concepts, components of traffic simulation, mathematical simulation model development,macroscopic, microscopic, and mesoscopic simulation models, software for simulation, calibration and validation simulation model, examples.

Learning Resources:

Textbooks:

1. Fundamentals of Transportation and Traffic Operations, CS Daganzo -Emerald, Inc., 2008.
2. Introduction to Modern Traffic Flow Theory and Control, Boris S. Kerner, Springer, 2009, First Edition.
3. Traffic Flow Theory and Control, Drew, DR., McGraw Hill Book Company, 1976.

Reference Books:

1. Highway Capacity Manual, Transportation Research Board, Washington, DC, 2010.
2. Principles of Highway Engineering and Traffic Analysis, Fred L. Mannering, and Scott S. Washburn,Jhon Wiley& Sons, 2013, Fifth Edition.
3. Traffic Engineering, Roger P. Roess, Elena S. Prassas, and William R. McShane, Pearson, 2019, Fifth Edition.
4. Traffic Flow Fundamentals, May, A.D., Prentice Hall, 1990 (Digitized in 2007)
5. Traffic Flow Theory: A Monograph, Gerlough DL and Huber MJ., TRB special report 165, 1992.

Online Resources:

1. https://www.rms.nsw.gov.au/business-industry/partners-suppliers/documents/technical-manuals/modellingguidelines.pdf
2. https://www.cityservices.act.gov.au/__data/assets/pdf_file/0009/1539576/ACT-Traffic-Microsimulation-Modelling-Guidelines.pdf

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CE5671	TRANSPORT ECONOMICS AND PROJECT APPRAISAL	3-0-0: 3

Pre-Requisites: Nil

Course Outcomes:

At the end of the course, students will be able to

CO1	Differentiate macro and microeconomic principles.
CO2	Quantify benefits and costs of transport projects and carry out economic analysis.
CO3	Evaluate transport projects.
CO4	Estimate the life cycle cost of transport projects.
CO5	Appraise various financial models for the development of transport infrastructure.

Course Articulation Matrix:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	-	-	-
CO2	3	3	2	-	-	-
CO3	3	3	2	2	1	-
CO4	3	3	3	1	-	-
CO5	3	3	2	2	1	1

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Transport Economics:

Population, Review 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, Fixed, variable, marginal, and average cost, opportunity cost, shadow price, the value of time, social cost of transportation, congestion as well as pollution cost, RUCS Models for Costs and Benefits, Methods of Economic Analysis; Suitability, Analysis for Null Alternative.

System Selection and Evaluation:

Framework of Evaluation, Measures of effectiveness of economic analysis, Other Evaluation Procedures - Traditional Economic Analysis, the concept of consumer surplus, equity issues in investment, decision making, Delphi Technique, Multi-Criteria Evaluation, Case Studies.

Life Cycle Cost Analysis:

Factors considered for Life Cycle Cost Analysis; data requirements for highway project feasibility analysis, the establishment of technical/ economic/ financial feasibility of a highway project, social benefits, fundamental aspects of depreciation, conventional and modified depreciation methods, examples of depreciation methods.

Financial Analysis – Private Sector Participation:

BOT, BOOT, BOLT Projects – Case history – Project Planning – Project System Management – Project Implementation, financial analysis in the public and private sector, revenue generation enhancement techniques, Budgetary and Control; Viability Gap Funding-Highway project, corridor project, and system projects, special purpose vehicles financing.

Learning Resources:

Textbooks:

1. Economic Analysis for Transportation: A Guide for Decision Makers, Robley E. Winfrey, International Textbook Co., Northwestern University, 1971 (Digitized in 2011).
2. Theory and Applications of Economics in Highway and Transport Planning, Maitri, V., Sarkar, P.K., Standard Publishers Distributors, 2010, First Edition.
3. Transport Economics (Critical Concepts in Economics), Hensher, D.A., Routledge 2011, First Edition.

Reference Books:

1. Manual on Economic Evaluation of Highway Projects in India, IRC: SP30, Indian Roads Congress, New Delhi, 2019.
2. Transportation Planning: Principles, Practices and Policies, Sarkar, P.K., Maitri, V., Joshi, G.J., PHI Learning, 2017, Second Edition.
3. Urban Transport: Planning and Management, Jain A.K., APH Publishing Corporation, 2008.

Online Resources:

1. https://dspace.mit.edu/bitstream/handle/1721.1/107706/11-540j-fall-2006/contents/lecture-notes/index.htm
2. https://nptel.ac.in/courses/105/107/105107067/

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CE5672	TRANSPORTATION NETWORK ANALYSIS	3-0-0: 3

Pre-Requisites: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.

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Basics of Transport Networks:

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, Generalized 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, Sensitivity of user equilibrium, and stochastic user equilibrium methods. Combined trip distribution and assignment, Combined mode choice, assignment, discrete choice models, Application to

route choice, Estimating OD matrices, Estimating demand functions, Theory of congestion pricing, Path flows, link flows, Path-based and origin-based methods.

Learning Resources:

Textbooks:

1. Transportation Network Analysis, Michael G.H. Bell and YasunoriLida, J. Wiley Publishers, 1997.
2. Urban Transportation Networks: Equilibrium Analysis with Mathematical Programming Methods, Yosef Sheffi, Prentice Hall Publishers, 1985. http://web.mit.edu/sheffi/www/selectedMedia/sheffi_urban_trans_networks.pdf

Reference Books:

1. Network Flows, Ravindra K Ahuja, Thomas L Magnanti, Creative Media Partners, LLC, 2018.
2. Transportation and Network Analysis: Current Trends: Miscellanea in Honor of Michael Florian, Michael Alexander Florian, Michel Gendreau, Patrice Marcotte, Springer Publisher, 2002.

Online Resources:

1. https://transportgeography.org/contents/chapter2/geography-of-transportation-networks/
2. https://trid.trb.org/view/573501

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CE5698	SEMINAR – II	0-0-2: 1

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, students will be able to

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

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

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

Learning Resources:

Textbooks:

Reference Books:

1. Research Articles / Reports available on the Internet
2. Transportation Engineering Journals
3. Transportation Engineering Textbooks and Handbooks

Online Resources:

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. http://onlinepubs.trb.org/onlinepubs/circulars/ec194.pdf
4. Instructor Resources: Seminar Proposal Guidelines, SAE International; http://www.sae.org/training/seminars/instructorzone/proposalguidelines.pdf

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CE6647	COMPREHENSIVE VIVA-VOCE	0-0-4: 2

Pre-Requisites: Both I & II Semester coursework 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	Analyze real-life transportation problems with theoretical knowledge learned.
CO4	Interpret and Articulate solutions to real-life transportation problems.

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

The entire course of study (All the required courses studied) up to II Semester of I Year.

Learning Resources:

Textbooks:

1. Reading Material of all the courses.

Reference Books:

A. Case Studies / Consultancy Reports.

Online Resources:

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CE6649	DISSERTATION PART - A	0-0-24: 12

Pre-Requisites:Both I & II Semester coursework of I Year should be completed.

Course Outcomes:

At the end of the course, students will be able to

CO1	Appraise Research Problem Statement.
CO2	Evaluate literature critically in a chosen area of research & establish Scope of work.
CO3	Develop Study Methodology.
CO4	Plan and carryouta pilot study.

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

There is no prescribed syllabus. Students are required to search, collect and review various research articles published in their 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.

Learning Resources:

Textbooks:

1. Writing Your Dissertation, Derek Swetnam, Oxford, UK, 2000, Third Edition.

Reference Books:

1. Conference / Seminar Proceedings.
2. Handbooks / Research Digests.
3. Journal Publications.

Online Resources:

1. https://www.scribbr.co.uk/category/thesis-dissertation/
2. https://www.bolton.ac.uk/leaponline/Documents/LEAP-Printables/Writing-a-Dissertation.pdf
3. https://www.unk.edu/academics/gradstudies/admissions/grad-files/Grad%20Files/ThesisGdInsFinal08.pdf

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CE6699	DISSERTATION PART - B	0-0-40: 20

Pre-Requisites:

1. Both I & II Semester coursework 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	Appraise Research Problem Statement.
CO2	Evaluate literature critically in a chosen area of research & Establish a Scope of work.
CO3	Formulate Study Methodology.
CO4	Compile database with relevant field studies/laboratory tests.
CO5	Develop appropriate models and discuss solutions.

Course Articulation Matrix:

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

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

There is no prescribed syllabus. Students are required to search, collect and review various research articles published in their 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.

Learning Resources:

Textbooks:

1. Writing Your Dissertation, Derek Swetnam, Oxford, UK, 2000, Third Edition.

Reference Books:

1. Conference / Seminar Proceedings.
2. Handbooks / Research Digests.
3. Journal Publications.

Online Resources:

1. https://www.scribbr.co.uk/category/thesis-dissertation/
2. https://www.bolton.ac.uk/leaponline/Documents/LEAP-Printables/Writing-a-Dissertation.pdf
3. https://www.unk.edu/academics/gradstudies/admissions/grad-files/Grad%20Files/ThesisGdInsFinal08.pdf

NOTE: Refer to the following link for the guidelines to prepare dissertation report:
https://www.nitw.ac.in/main/PGForms/NITW/

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