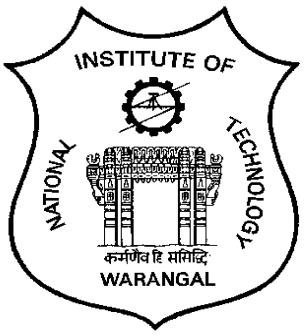
NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL



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

Effective from Academic Year: 2019-20

DEPARTMENT OF CIVIL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
WARANGAL – 506004, TELANGANA
July 2019

NATIONAL INSTITUTE OF TECHNOLOGY, WARANGAL

VISION

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

MISSION

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

DEPARTMENT OF CIVIL ENGINEERING

VISION

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

MISSION

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

NATIONAL INSTITUTE OF TECHNOLOGY, WARANGAL
DEPARTMENT OF CIVIL ENGINEERING

M.Tech. Program in TRANSPORTATION ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

The graduating students of the Transportation Engineering 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 transportation industry, research, government and other fields.
PEO3.	Demonstrate good communication and management skills, and leadership qualities to work effectively and lead interdisciplinary teams in rapidly changing and diverse workplaces.
PEO4.	Engage in lifelong learning by participating in technical events, conferences, workshops, seminars, events of professional societies, and allied activities for both personal development and career growth.
PEO5.	Execute complex transportation projects and evaluate their impact on the society with an understanding of professional ethics and social responsibility.

PROGRAM OUTCOMES (POs)

The Graduates of the Transportation Engineering program will demonstrate the following:

PO1	An ability to engage in critical thinking and pursue research / investigations and development to solve practical problems.
PO2	An ability to communicate effectively on complex engineering activities with the engineering community and with society at large, write and present technical reports.
PO3	An ability to demonstrate higher level of professional skills to tackle multidisciplinary and complex problems related to Transportation Engineering.
PO4	An ability to plan, analyze, design, synthesize, execute, and manage complicated transportation infrastructure projects within local and global context in a sustainable manner.
PO5	An ability to provide cost effective engineered solutions for transportation related societal problems, with good professional and ethical responsibility.
PO6	An ability to function as a member of a multi-disciplinary team and to assume leadership role in executing transportation infrastructure projects, while updating skill sets required continuously throughout the professional life

Mapping of PEOs with POs

Program Education Objectives		Program Outcomes					
		PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PEO1	Plan, design, construct, operate and maintain safe, cost effective and sustainable transportation systems in the context of environmental, economic and social requirements.	**3**	**1**	**3**	**3**	**3**	**1**
PEO2	Become competent professionals to fit into a broad range of career opportunities available in transportation industry, research, government and other fields.	**3**	**1**	**3**	**3**	**3**	**1**
PEO3	Demonstrate good communication and management skills, and leadership qualities to work effectively in and lead interdisciplinary teams in rapidly changing and diverse workplaces.	**1**	**3**	**1**	**2**	**1**	**3**
PEO4	Engage in lifelong learning by participating in technical events, conferences, workshops, seminars, events of professional societies, and other activities for both personal development and career growth.	**2**	**3**	**1**	**2**	**2**	**3**
PEO5	Execute complex transportation projects and evaluate their impact on the society with an understanding of professional ethics and social responsibility.	**3**	**1**	**2**	**2**	**3**	**1**

Note: 1: Slightly 2: Moderately 3: Substantially

SCHEME OF INSTRUCTION AND EVALUATION

M.Tech. (Transportation Engineering): Course Structure

I Year M. Tech. (T.E.) I – Semester

Sl. No.	Course Code	Course Title	L	T	P	C
1	CE5601	Urban Transportation Planning	3	0	0	3
2	CE5602	Traffic Analysis	3	0	0	3
3	CE5603	Pavement Analysis and Design	3	0	0	3
4		Elective – I	3	0	0	3
5		Elective – II	3	0	0	3
6		Elective – III	3	0	0	3
7	CE5604	Traffic Measurements Laboratory	0	1	2	2
8	CE5605	Transportation Analytics Laboratory	0	1	2	2
9	CE5641	Seminar-I	0	0	2	1
		TOTAL	**18**	**2**	**6**	**23**

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

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

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

I Year M. Tech. (T.E.) II – Semester

Sl. No.	Course Code	Course Title	L	T	P	C
1	CE5651	Public Transportation Systems	3	0	0	3
2	CE5652	Geometric Design of Highways and Streets	3	0	0	3
3	CE5653	Pavement Construction and Evaluation	3	0	0	3
4		Elective – IV	3	0	0	3
5		Elective – V	3	0	0	3
6		Elective – VI	3	0	0	3
7	CE5654	Pavement Materials and Evaluation Laboratory	0	1	2	2
8	CE5655	Transportation SoftwareLaboratory	0	1	2	2
9	CE5691	Seminar – II	0	0	2	1
		TOTAL	**18**	**2**	**6**	**23**

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

Sl. No.	Course Code	Course Title
1	CE5661	Advanced Travel Demand Modelling
2	CE5662	GIS for Transportation
3	CE5663	Intelligent Transportation Systems
4	CE5664	Landuse and Transportation Planning
5	CE5665	Pavement Management System
6	CE5666	Road Asset Management
7	CE5667	Road Safety Engineering
8	CE5668	Traffic Flow Modeling and Simulation
9	CE5669	Transport Economics and Project Appraisal
10	CE5670	Transportation Logistics
11	CE5671	Transportation Networks and Optimization
12	CE5672	Transportation Systems Management

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

Sl. No.	Course Code	Course Title	Credits
		II Year M. Tech. (T.E.) I – Semester	
1		Industrial Training (8-10 weeks) Optional	
2	CE6642	Comprehensive Viva Voce	2
3	CE6649	Dissertation Part – A	9
		II Year M. Tech. (T.E.) II – Semester	
4	CE6699	Dissertation Part – B	18

Sl. No.	Courses	No. of Courses Offered					Credits
		I Sem.	II Sem.	III Sem.	IV Sem.	Total	
A	**Core Courses (≥24 credits)**						
1.	Theory courses	3	3	-	-	6	18
2.	Laboratory Courses	2	2	-	-	4	8
3.	Seminars	1	1	-	-	2	2
4.	Comprehensive Viva Voce	-	-	1	-	1	2
	Sub Total	**6**	**6**	**1**	**-**	**13**	**30**
B	**Elective courses (≥18 credits)**	**3**	**3**	**-**	**-**	**6**	**18**
C	**Dissertation (= 27 credits)**	**-**	**-**	**1**	**1**	**2**	**27**
	Grand Total	**9**	**9**	**2**	**1**	**21**	**75**

DETAILED SYLLABUS FOR EACH COURSE

M.Tech (Transportation Engineering) I Semester

CE5601: URBAN TRANSPORTATION PLANNING

Course Type	Theory Course – Core			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

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

CO1: Identify urban transportation problems.
CO2: Estimate urban travel demand.
CO3: Plan urban transport networks.
CO4: Identify urban transport corridors.
CO5: Prepare urban transportation plans.

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Urban Transportation Problems & Policy **4**

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

2. Travel Demand Modelling **6**

Trends, Overall Planning process, Long term - Short term planning, Demand Function, Independent Variables, Travel Attributes, Assumptions in Demand Estimation, Sequential, and Simultaneous Approaches, Aggregate and Disaggregate Techniques, Tour based models, and Activity based models.

3. Data Collection and Inventories **5**

Collection of data – Organization 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 Ownership

4.	**Trip Generation Models** UTPS Approach, Trip Generation Analysis: Zonal Models, Category Analysis, Household Models, Trip Attraction models, Commercial Trip Rates	**5**
5.	**Trip Distribution Models** Trip Distribution: Growth Factor Methods, Gravity Models, Opportunity Models, Time Function Iteration Models.	**5**
6.	**Mode Split Analysis** Mode Choice Behavior, Competing Modes, Mode Split Curves, Models and Probabilistic Approaches – Logit Model	**5**
7.	**Traffic Assignment Techniques** Diversion Curves, 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, Multipath Assignment Technique.	**6**
8.	**Corridor Identification - Plan preparation and evaluation** Master plans, Selection of Corridor, Corridor Identification, Corridor deficiency Analysis; TOD; Travel Forecasts to Evaluate Alternative Improvements, Impacts of New Development on Transportation Facilities; Pivot Point Analysis, Environmental and Energy Analysis.	**6**
	Total Instruction / Contact Hours	**42**

Learning Resources:

A. Readings and References:

1. C. Jotin Khisty and B. Kent Lall, Transportation Engineering: An Introduction, 3rd Edition, Pearson, 2016.
2. C.S. Papacostas and P.D. Prevedouros, Transportation Engineering and Planning, Third Edition, Prentice Hall of India Pvt. Ltd., 2015
3. Hutchinson, B.G., Principles of Urban Transport Systems Planning, McGraw Hill, 1974.
4. Juan de Dios Ortuzar and Luis G. Willumsen, *Modelling Transport, 4th Edition*, John Wiley and Sons, 2011.
5. Michael D. Meyer, Transportation Planning Handbook, Fourth Edition, Institute of Transportation Engineers, John Wiley & Sons Inc., 2016
6. Michael D. Meyor and Eric J. Miller, Urban Transportation Planning: A decision oriented Approach, Second Edition, McGraw Hill, 2001.
7. Michael J. Bruton, Introduction to Transportation Planning, UCL Press, London, UK, 2000.

B. E-Learning and Web References:

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

Course Type	Theory Course – Core			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

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

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

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Components of Traffic System **4**

Introduction, Human-vehicle-environment system, Characteristics of road users, characteristics of vehicles, Characteristics of Pedestrians.

2. Traffic Data Collection studies **4**

Traffic study components, types of data; Volume studies; Speed studies; Travel time and delay studies; Intersection studies, Pedestrian studies; Parking studies, Advanced methods: GPS, Instrumented Vehicles, Image Processing, Bluetooth, Infrared methods, Sample selection;

3. Characteristics of Traffic **6**

Fundamental parameters of traffic and relationships; Time headways, Interrupted and un-interrupted traffic; Microscopic and macroscopic characteristics of traffic stream, Vehicle arrival and speed distributions.

4. Macroscopic Traffic Stream Models **6**

Stream flow fundamentals; family of models, Continuity equation; Waves in traffic, Platoon diffusion, Regime based Macroscopic models.

5. Microscopic Traffic Stream Models **6**

Car-following models; Gap acceptance models; Mixed traffic flow behaviour: Non-lane based movement, Heterogeneity, Applications.

6. Capacity Analysis **16**

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

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. C. Jotin Khisty and B. Kent Lall, Transportation Engineering: An Introduction, 3rd Edition, Pearson, 2016.
2. C.S. Papacostas and P.D. Prevedouros, Transportation Engineering and Planning, Third Edition, Prentice Hall of India Pvt. Ltd., 2015
3. Chakroborty Partha, Das Animesh, Principles of Transportation Engineering, PHI Learning Pvt. Ltd., 1st Edition, 2009.
4. Highway Capacity Manual 2010, Transportation Research Record, Transportation Research Board, Washington, D.C., 2010
5. Indian Highway Capacity Manual (Indo HCM), CSIR-CRRI, New Delhi, 2017.
6. L.R. Kadiyali, Traffic Engineering and Transportation Planning, Khanna Publishers, 2012.
7. Louis J. Pignataro, Traffic Engineering: Theory and Practice 1st Edition, Prentice Hall, 1973
8. May, A.D. Traffic Flow Fundamentals, 1st Edition, Prentice Hall, 1990.
9. Nicholas J. Garber and Lester A. Hoel, Traffic and Highway Engineering, 5th edition (SI), Cengage Learning, Reprint 2017.
10. Roger P. Roess, Elena S. Prassas and William R. McShane, Traffic Engineering, Fifth Edition, Pearson, 2019.

B. E-Learning and Web References:

1. https://nptel.ac.in/downloads/105101008/

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CE5603: PAVEMENT ANALYSIS AND DESIGN

Course Type	Theory Course – Core			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

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

CO 1: Analyze the stresses and strains in a flexible pavement using multi-layered elastic theory, and the KENLAYER program.
CO 2: Analyze stresses and strains in a rigid pavement using Westergaard's theory, and the KENSLABS program.
CO 3: Design a flexible pavement using IRC, Asphalt Institute, and AASHTO methods.
CO 4: Design a rigid pavement using IRC, and AASHTO methods.

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):						
CO\PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	3	1	2	3	3	1
CO 2	3	1	2	3	3	1
CO 3	3	1	2	3	3	1
CO 4	3	1	2	3	3	1

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Pavement Types and Materials **3**

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

2. Stresses in Flexible Pavements **9**

Layered system concepts; stress solution for one, two and three layered systems; fundamental design concepts; stress analysis in flexible pavements using KENLAYER.

3. Stresses in Rigid Pavements **6**

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

4. Factors Affecting Pavement Design **6**

Variables considered in pavement design; classification of axle types, standard and legal axle loads, tyre pressure, contact pressure, ESWL, EWLF and EAL concepts; traffic analysis: ADT, AADT, truck factor, growth factor, lane distribution factor, directional distribution factor and vehicle damage factor.

5. Design of Flexible Pavements **9**

IRC method of flexible pavement design; Asphalt Institute's methods with HMA and other base combinations; AASHTO method of flexible pavement design; design of flexible pavement shoulders.

6. Design of Rigid Pavements **9**

IRC method of plain jointed and continuously reinforced rigid pavement design; AASHTO method of rigid pavement design; Design of rigid pavement shoulders.

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. Asphalt Institute. Thickness Design – Asphalt Pavements for Highways and Streets Manual Series No. 1 (MS-1), Asphalt Institute, Kentucky, USA, 1999.
2. Huang, Y.H. Pavement Analysis and Design, Second Edition, Dorling Kindersley (India) Pvt. Ltd., New Delhi, India, 2008.
3. IRC: 37-2018. Guidelines for the Design of Flexible Pavements, The Indian Roads Congress, New Delhi, India, 2018.
4. IRC: 58-2015 Guidelines for the Design of Plain Jointed Rigid Pavements for Highways, The Indian Roads Congress, New Delhi, India, 2015.
5. Mallick, R.B. and T. El-Korchi Pavement Engineering – Principles and Practice, CRC Press, Taylor and Francis Group, Florida, USA, 2009.
6. Papagiannakis, A.T. and E.A. Masad, Pavement Design and Materials, John Wiley and Sons, New Jersey, USA, 2008.

7. Yoder, E.J. and M.W. Witczak Principles of Pavement Design, Second Edition, John Wiley and Sons, New York, USA, 1975.

B. E-Learning and Web References:

1. https://www.pavementinteractive.org/

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CE5604: TRAFFIC MEASUREMENTS LABORATORY

Course Type	Practical Course - Core			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	0	1	2	2
Evaluation:	Report	Written Test	Practical	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

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

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

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus	**Lab Hours**
Volume studies: Direction, Duration and Classification of Traffic Volume at Mid-Block Section and Intersections, Manual, and Mechanical Methods, Headway Distributions	**2**
Speed studies: Spot Speed Studies - Radar Speed Meters	**1**
Journey time and delay studies: Travel Time and Delay Studies by Floating Car Method	**1**
Gap acceptance studies: Study of Gaps, Lags, Critical Gaps at Intersections	**2**
Intersection delay studies: Delay Measurement at Uncontrolled Intersections and Signalised Intersections	**2**
Parking surveys: Parking Inventory and Turnover Studies	**1**
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	**2**
Highway Capacity Estimation: Videographic method, Dynamic PCU	**2**

Learning Resources:

A. Readings and References:

1. C. Jotin Khisty and B. Kent Lall, Transportation Engineering: An Introduction, 3rd Edition, Pearson, 2016
2. L.R. Kadiyali, Traffic Engineering and Transportation Planning, Khanna Publishers, 2012.
3. Louis J. Pignataro, Traffic Engineering: Theory and Practice 1st Edition, Prentice Hall, 1973
4. Roger P. Roess, Elena S. Prassas and William R. McShane, Traffic Engineering, Fifth Edition, Pearson, 2019.
5. Thomas R. Currin, Introduction to Traffic Engineering: Manual For data Collection & Analysis, 2nd Edition, CL Engineering, 2012.

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CE5605: TRANSPORTATION ANALYTICS LABORATORY

Course Type	Laboratory Course - Core			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	0	1	2	2
Evaluation:	Report	Written test	Practical	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

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

CO1: Exemplify the data types, sampling and choice of method to evaluate
CO2: Perform data analysis and its interpretation
CO3: Perform statistical significance tests using advanced tools and packages.
CO4: Calibrate and validate the theoretical relationships, and derive conclusions from the results.

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus	**Hours**
1. Data description and Sampling	**6**
Central tendency of data and descriptive analysis, data dispersion and shape, graphical representation using plots and identification of patterns, histograms and interpretation of results, sampling exercises, data storing, handling, cleaning, practice using tools and statistical packages.	
2. Statistical Data Analysis	**9**
Fitting probabilistic distributions, correlation analysis, simple linear and multiple-linear regressions, nonlinear regression analysis,	
3. Tests of significance	6
Non-parametric tests, test of significance, paired and unpaired parametric tests and evaluation, analysis of variance, univariate and multivariate analysis, practice with advanced tools and statistical packages.	
4. Data analysis using R:	**9**
Basics of R programming, summarizing data and analyzing probabilistic distributions with transportation data, mathematical modeling and hypothesis testing using R, practice with different transportation data	
Total Instruction / Contact Hours	30

Learning Resources:

A. Readings and References:

1. Bovas A., N. Nair U., Quality Improvement through Statistical Method, Springer Science & Business Media, 01-Aug-1998.
2. Clifford S., E. S. Park, Laurence R. R., Transportation Statistics and Micro-simulation, CRC Press, Taylor and Francis group, 2011.
3. John C., Software for Data Analysis: Programming with R, Stanford University, Springer, 2008.
4. Robert V. Hogg, and Elliot Tanis and Dale Zimmerman, *Probability and Statistical Inference*, 9th Edition, Pearson, 2014
5. Simon P. Washington, Matthew G. Karlaftis, Fred L Mannering, *Statistical and econometric methods for transportation data analysis*, Second Edition, CRC Press, 2010.
6. Yanchang Zhao, R and Data Mining: Examples and Case Studies, First Edition, Elsevier Inc., 2013.

B. E-Learning and Web References:

1. https://nptel.ac.in/courses/111105041
2. https://ocw.mit.edu/courses/sloan-school-of-management/15-062-data-mining-spring-2003/
3. https://www.coursera.org/specializations/statistics

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CE5641: SEMINAR – I

Course Type	Seminar – Core			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	0	0	2	1
Evaluation:	Weekly Reviews		End Sem.	Grading
Continuous	50%		50%	Relative
Pre Requisite Courses	Nil			

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

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

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Weeks**

1. There is no specific syllabus for this course. However, student can choose any topic, of his choice, pertaining to Transportation Engineering. Topic should be a relevant and currently researched one. Students are advised to refer articles published in current journals in the area of Transportation Engineering for choosing their seminar topics. Student should review minimum of 5 to 6 research papers relevant to the topic chosen, in addition to standard textbooks, handbooks, etc. Students are required to prepare a seminar report, in the standard format and give presentation to the Seminar Assessment Committee (SAC) in the presence of their classmates. It is mandatory for all the students to attend the presentations of their classmates. **14**

Total Instruction / Contact Weeks **14**

Learning Resources:

A. Readings and References:

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

B. E-Learning and Web References:

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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CE5611: ADVANCED PAVEMENT MATERIALS

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

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

CO 1: Determine the proportions of ingredients required for the mix design of both asphalt mixtures and cement concrete.
CO 2: Characterize the pavement materials including soil, aggregate, asphalt, cement, asphalt mixtures, cement concrete.
CO 3: Select appropriate asphalt binder for construction of a flexible pavement depending upon the traffic and climatic conditions.
CO 4: Choose appropriate stabilization technique for pavement applications.

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

CO\PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	1	2	3	3	1
CO 2	3	1	2	3	3	1
CO 3	3	1	2	3	3	1
CO 4	3	1	2	3	3	1

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Pavement Materials **3**

Materials used in pavement construction; conventional and nonconventional materials.

2. Aggregates **6**

Physical and mechanical properties of aggregates; blending of aggregates; alternate materials for conventional aggregates including natural, manufactured, industrial by-products, and waste materials.

3. Bituminous Binders **15**

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

4. Bituminous Mixtures **6**

Design of bituminous mixes using Marshall method, and SUPERPAVE method; types of bituminous mixes including hot mixes, cold mixes, warm mixes and applications; Permanent deformation, dynamic modulus, fatigue of bituminous mixes, moisture induced damage in bituminous mixes.

5. Cement and Cement Concrete **6**

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

6. Granular Materials and Stabilization **6**

Basic soil properties relevant to pavement applications; Resilient modulus of granular materials, modulus of subgrade reaction; Soil stabilization: use of lime, cement, bitumen, and other commercial stabilizers; Applications of Geosynthetics in pavements.

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. Asphalt Institute. Asphalt Mix Design Methods, Manual Series No. 2 (MS-2), Seventh Edition, Asphalt Institute, Kentucky, USA, 2014.
2. Huang, Y.H. Pavement Analysis and Design, Second Edition, Dorling Kindersley (India) Pvt. Ltd., New Delhi, India, 2008.
3. IRC: 44-2017 Guidelines for Cement Concrete Mix Design for Pavements, The Indian Roads Congress, New Delhi, India, 2017.
4. Kandhal, P.S. Bituminous Road Construction in India, PHI Learning Pvt. Ltd., New Delhi, India, 2016.
5. Ministry of Road Transport and Highways, Specifications for Road and Bridge Works, Fifth Edition, Indian Roads Congress, New Delhi, India, 2013.
6. Papagiannakis, A.T. and E.A. Masad, Pavement Design and Materials, John Wiley and Sons, New Jersey, USA, 2008.
7. Sherwood, P.T. Alternative materials in road construction, Thomas Telford, New York, USA, 1997.

B. E-Learning and Web References:

1. https://www.pavementinteractive.org/

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CE5612: AIRPORT INFRASTRUCTURE PLANNING AND DESIGN

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

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

CO 1: Analyze the effects of atmospheric variables on aircraft performance.
CO 2: Determine the orientation of the runways.
CO 3: Design the geometrics of the airport infrastructure.
CO 4: Prepare structural designs of runway, taxiway, and apron-gate area.
CO 5: Prepare a master plan for an airport.
CO 6: Prepare a plan of the airport terminal area.

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

CO\PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	2	2	3	3	1
CO 2	3	2	2	3	3	1
CO 3	3	2	2	3	3	1
CO 4	3	2	2	3	3	1
CO 5	3	2	2	3	3	1
CO 6	3	2	2	3	3	1

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Airport Planning and Forecasting **6**

Airport planning: commercial service aviation, air cargo, and general aviation; civil aviation airports; major acts and policies of the Ministry of Civil Aviation in India; Aviation organizations and functions: Federal Aviation Administration, International Civil Aviation Organization, Directorate General of Civil Aviation, Airports Authority of India; Airport planning studies: airport system plan, airport site selection, airport master plan, airport project plan; continuous planning process; Forecasting methods: time series method, market share method, econometric modelling; Forecasting requirements and applications.

2. Aircraft Characteristics **6**

Landing gear configurations, aircraft weight, engine types; Atmospheric conditions affecting aircraft performance: air pressure, temperature, wind speed and direction; Aircraft performance characteristics: speed, payload and range, runway performance, declared distances, wingtip vortices.

3. Air Traffic Management **3**

Air traffic separation rules: vertical separation, flight altitudes, longitudinal separation, and lateral separation; navigational aids: ground based systems, satellite based systems.

4. Geometric Design of the Airfield **12**

Airport classification: utility airports, transport airports; Runways: runway configurations, runway orientation, wind rose, estimating runway length, sight distance and longitudinal profile, transverse gradient, airfield separation requirements, obstacle clearance requirements; Taxiways and taxi lanes: widths and slopes, taxiway and taxi lane separation requirements, sight distance and longitudinal profile, exit taxiway geometry, location of exit taxiways, design of taxiway curves and intersections, end-around taxiways; Aprons: holding aprons, terminal aprons and ramps, terminal apron surface gradients; Control tower visibility requirements.

5. Structural Design of Airport Pavements **3**

Design of flexible and rigid pavements using FAARFIELD.

6. Airport Lighting, Marking, and Signage **6**

Requirements of visual aids, approach lighting system configurations, visual approach slope aids, threshold lighting; Runway lighting, taxiway lighting; Runway and taxiway marking, airfield signage.

7. Planning and Design of the Terminal Area **6**

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

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

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

B. E-Learning and Web References:

1. https://www.faa.gov/airports/engineering/design_software/
2. https://www.envitrans.com/how-to-interpret-a-wind-rose.php

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CE5613: ENVIRONMENTAL IMPACTS OF TRANSPORTATION

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

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

CO1: Examine the effects of transportation systems on the environment.
CO2: Estimate air pollution and noise pollution caused by a transportation system.
CO3: Describe the EIA study and its process.
CO4: Apply suitable methods to carry out a detailed EIA study.

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Environment, interaction and Attributes **9**

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)

2. Environmental Standards, Laws & Regulations **6**

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

3. Prediction of Air & Noise Pollution **10**

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

4. Environmental Impact Assessment and Statement (EIA & EIS) **10**

Objectives of EIA, Advantages and Limitations of EIA; Overview of Methodologies Adhoc, Checklist, Matrix, Network, Overlays, Benefit Cost Analysis, Choosing a Methodology, Review Criteria; IRC Code

5. Mitigation Policies and Measures **7**

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

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

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

B. E-Learning and Web References:

1. http://www.nap.edu/catalog/10354.html
2. https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-017-computing-and-data-analysis-for-environmental-applications-fall-2003
3. https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-963-environmental-engineering-applications-of-geographic-information-systems-fall-2004

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CE5614: FREIGHT TRANSPORTATION SYSTEMS

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

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

CO1: Estimate demand for freight at city and regional level
CO2: Develop route plans and schedules
CO3: Design intermodal networks for freight travel
CO4: Deploy ITS technologies for efficient flow of freight

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):						
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	2	3	1	1
CO2	3	1	1	2	3	1
CO3	3	1	3	3	3	1
CO4	2	1	2	2	2	2

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Characteristics of Freight Transport **6**

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

2. Freight Demand Estimation **12**

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

3. Freight Transport Planning and Operations **10**

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

4. Intermodal Freight Transport **8**

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

5. ITS for Freight Transport **6**

Introduction to ITS, Role of ITS, ITS components applicable to Goods travel, case studies

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. David Lowe, Intermodal Freight Transport, First Edition, Elsevier Butterworth-Heinemann Publishers, 2006.
2. Konstadinos G. Goulias, Editor, Transportation Systems Planning: Methods and Applications. CRC Press, 2003.
3. Lester A. Hoel, Genevieve Giuliano and Michael D. Meyer, Intermodal Transportation: Moving Freight in a Global Economy, Transportation Research Forum, Eno Center for Transportation, Washington DC, 2016
4. Lorant Tavasszy and Gerard De Jong, Modelling Freight Transport, 1st Edition, Elsevier Publishers, 2013.
5. Meyer Kutz, Editor, Handbook of Transportation Engineering, Second Edition, McGraw-Hill Publishers, 2011
6. Moshe Ben-Akiva, Hilde Meersman and Eddy Van de Voorde, Freight Transport Modelling, Emerald Group Publishing, 2013

7. Petros A. Ioannou, Editor, Intelligent Freight Transportation, 1st Edition, CRC Press, 2008
8. Tolga Bektas, Freight Transport and Distribution: Concepts and Optimisation Models, 1st Edition, CRC Press, 2017

B. E-Learning and Web References:

1. NCFRP Report 23, Synthesis of Freight Research in Urban Transportation Planning, TRB, Washington, 2013. http://onlinepubs.trb.org/onlinepubs/ncfrp/ncfrp_rpt_023.pdf

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CE5615: LOW VOLUME ROADS

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

Course Outcomes (COs): At the end of the course, students will be able to	
CO1:	Plan the rural road network.
CO2:	Determine the sight distance, horizontal curvature, super elevation, grades, visibility on vertical curves, cross section elements.
CO3:	Justify the geometric design standards adopted for low volume roads
CO4:	Prepare appropriate data formats and conduct engineering surveys
CO5:	Design of flexible and rigid pavements for low volume roads

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Introduction to Low Volume Roads **4**

Significance, definition, characteristics of LVRs, common terminology used in LVRs, rural roads vision 2025, PMGSY, development of LVRs in India and International scenario of LVRs developments.

2. Low Volume Road Network Planning **6**

Master plan and core network concepts, concepts of network planning of LVRs, detailed project report preparation of LVRs, NATPAC model, CRRI model, FBRNP model, central place theory and GIS based network planning.

3. Geometric Design of LVRs **8**

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

4. Marginal Materials **10**

Conventional materials, marginal and waste materials, Source of marginal materials, marginal materials guidelines, subgrade soil stabilization, dealing with poor subgrades, Tests on aggregates and bitumen, framework for the appropriate use of marginal materials, Geosynthetic types and manufacture, tests, functions.

5. Pavement Design of LVRs **10**

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

6. Construction and Specifications **4**

Case studies of waste material utilization in rural roads, low cost techniques for rural road construction, MoRD specifications.

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. Bruton, M. J., *Introduction to Transportation Planning*, UCL press, London, UK, 1992.
2. Ethiopian Roads Authority, Design Manual for Low Volume Roads, Parts A-G: Gordon Keller & James Sherar, Low-Volume Roads Engineering: Best Management Practices – Field Guide, USDA Forest Service / USAID, 2003. IRC SP 20: Rural road manual, Indian road congress, New Delhi, 2002.
3. MoRD, Specifications for Rural Roads, Ministry of Rural development, Fifth revision, Indian Road Congress, New Delhi, 2014.
4. S.K. Khanna, C.E.G. Justo, A. Veeraragavan, Highway Engineering, Nem Chand & Brothers, 2014.

B. E-Learning and Web References:

1. http://www.icafrica.org/knowledge-publications/article/design-manual-for-low-volume-roads-parts-a-g-116/
2. http://www4.worldbank.org/afr/ssatp/Resources/HTML/LVSR/English/Added-2007/2003-LVR-Engineering-FieldGuide-USA-by-GKeller.pdf
3. http://www.trb.org/Calendar/Blurbs/175976.aspx

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CE5616: RAILWAY INFRASTRUCTURE PLANNING AND DESIGNING

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minor	Mid exam	End exam	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

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

CO1: Describe the procedure of railway infrastructure planning.
CO2: Examine the factors governing planning and design of railway infrastructures.
CO3: Design the railway track system and signaling system.
CO4: Carryout railway tracks maintenance by advanced methods and apply remedial measures to ensure safety.

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Planning of railway network **6**

Operational system, historical background, plans and developments, policy and standards, traffic forecasts and surveys, railway alignment, project appraisal and organization setups.

2. Component of railway track and rolling stock: **6**

Permanent way, forces acting on rails, function of rails, rail fixtures and fastenings, sleepers and ballast, rail joints, elements of junctions and layouts, types of traction, locomotives and other rolling stock, tractive effort and hauling power of locomotives.

3. Geometric design of railway track, construction and maintenance: **9**

Field investigation, right of way and formation, geometric design elements and standards, speeds computation, string lining of curves, grade compensation, railway cant and cant deficiency, traction, practice with examples.

Special considerations and practices, track laying, inspection and maintenance, maintenance tools, maintenance of rail surface, track drainage, track circuited lengths, track tolerances, ballast confinement and track maintenance, renewal works.

4. Signalling and interlocking: **3**

Objectives, classifications, signaling systems, mechanical and electrical signaling systems, systems for controlling train movement, interlocking, and modern signaling.

5. Railway accidents and safety: **6**

Cause of train accidents, types of collision and derailment, restoration of traffic, safety measures, disaster management, level crossing and related accidents, remedial measures.

6. Railway Station and Yards: **6**

Site selection, facilities, classification, platforms, building areas, types of yards, sidings, foot over bridges and subways, loading gauge, end loading ramps, locomotive sheds, triangles, buffer stop, scotch block, derailing switch, sand hump, fouling mark.

7. High Speed Railways: **6**

Modernization of railways, effect of high speed track, vehicle performance on track, high speed ground transportation system, ballastless track, elevated railways, underground, and tube railways.

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. Agarwal, M.M. Indian Railway Track, Prabha & Co., New Delhi, India, 1988.
2. Chandra S. and M. Agrawal, Railway Engineering, Second Edition, Oxford University Press, 2013.
3. Clifford F. Bonnett, Practical Railway Engineering, 2nd edition, imperial college press, London, 2005.
4. Gupta, B.L. Text Book of Railway Engineering, Standard Publishers, New Delhi, India, 1982.
5. Mundrey, J. S., Railway Track Engineering, Fourth Edition, TATA McGraw- Hill, New Delhi, 2009
6. Rangwala, S.C. Principles of Railway Engineering, Charotar Publishing House, Anand, India, 2009.
7. Saxena S.C. and S.P. Arora, A text book of Railway Engineering, Dhanpat Rai, 2010.

B. E-Learning and Web References:

1. https://nptel.ac.in/courses/105107123/
2. https://www.edx.org/course/railway-engineering-an-integral-approach-2

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CE5617: REGIONAL TRANSPORTATION PLANNING

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

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

CO1: Appreciate regional dynamics w.r.t. national and regional development planning
CO2: Delineate regions for transportation planning.
CO3: Estimate demand for both regional and intercity passenger travel.
CO4: Estimate regional goods travel demand.
CO5: Plan and evaluate regional transportation networks.

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Regional Dynamics **8**

Goals and achievements, challenges and opportunities, regional patterns and imbalances, strategies of regional plans and policies, recent trends, Christaller's central place theory, the growth pole hypothesis, identification of blocks and location of socioeconomic activities with man's diagram, Bisection Methods, population threshold analysis, Regional Planning and National development planning, Urban nodes, Multi Nuclei

2. Delineation of Regions **8**

Concept of Region, Types of regions, Hierarchy of activities and 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 and gravitational analysis.

3. Regional Passenger Travel Demand Estimation **8**

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

4. Regional Goods Travel Demand Estimation **8**

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

5. Regional Network Planning **10**

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

Total Instruction / Contact Hours **42**

Learning Resources:

B. Readings and References:

1. A.G. Wilson, Urban and Regional Models in Geography and Planning, John Wiley & Sons Inc, 1974.
2. C. Jotin Khisty and B. Kent Lall, Transportation Engineering: An Introduction, 3rd Edition, Pearson, 2016.
3. C.S. Papacostas and P.D. Prevedouros, Transportation Engineering and Planning, Third Edition, Prentice Hall of India Pvt. Ltd., 2015.
4. Dicky J.W., Metropolitan Transportation Planning, Script Book Co., Washington, D.C., 1975.
5. John Glasson, An Introduction to Regional Planning: Concepts, Theory and Practice, 3rd Revised Edition, Taylor & Francis Ltd., 1998
6. Lewis B. Keeble, Principles and Practices of Town and Country Planning, 4th Edition, Estates Gazette, 1969 (Digitized 2010)
7. Meyer Kutz, Editor, Handbook of Transportation Engineering, Second Edition, McGraw-Hill Publishers, 2011
8. Michael D. Meyer, Transportation Planning Handbook, Fourth Edition, Institute of Transportation Engineers, John Wiley & Sons Inc., 2016.

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CE5618: SUSTAINABLE TRANSPORTATION

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

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

CO1: Differentiate sustainable transportation systems from non-sustainable transportation systems
CO2: Develop a sustainable transportation system.
CO3: Evaluate NMT modes
CO4: Plan for pedestrian and bicycle facilities
CO5: Appreciate and recommend appropriate policies and technologies to enhance the sustainability of transportation.
CO6: Choose appropriate mitigation measures suitable to local conditions

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Problems of Sustainability in Transport **5**

Energy use in transport sector; Transport and climate change; Greenhouse gas emissions, urban air quality, Congestion and sustainability

2. Planning for Sustainability **5**

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

3. Evaluation of Non-Motorised Transportation **5**

Surveys, Demand Estimation and Analysis; Crash Data, Barrier Effect; Cycling Condition Evaluation Techniques; Pedestrian Condition Evaluation Techniques; Prioritizing Improvements and Selecting Preferred Options.

4. Planning for Pedestrians **5**

Types of pedestrians and Characteristics; Pedestrian facilities and planning; Pedestrian standards and improvements; Pedestrian safety programs

5. Planning for Bicyclists **5**

Types of cyclists and Bikeways; Integrating cycling into roadway planning; Bicycle network planning; Accommodating cyclists on rural roads; Bicycle Parking/storage Facilities; Roadway maintenance for cyclists.

6. Sustainable Policies **5**

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

7. Sustainable Technologies **5**

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

8. Nationally Appropriate Mitigation Actions **7**

Mobility Management policies, Supporting Bicycling, Creating pedestrian friendly facilities, encouraging Public Transportation

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. Black, W.R., Sustainable transport: Problems and Solutions. Gulford Press, New York, 2010.
2. Cervero, R. Accessible Cities and Regions: A Framework for Sustainable Transport and Urbanism in the 21st Century. Center for Future Urban Transport, Institute of Transportation Studies, University of California, Berkeley, 2005.
3. Francis Vanek, Largus Angenent, James Banks, Ricardo Daziano and Mark Turnquist, Sustainable Transportation Systems Engineering, 1st Edition, McGraw Hill, 2014
4. Mehrdad Ehsani, Fei-Yue Wang and Gary L. Brosch (Eds.) Transportation technologies for sustainability, 2013.
5. Preston L. Schiller, Eric C. Brunn and Jeffrey R. Kenworthy. An Introduction to Sustainable Transportation: Policy, Planning and Implementation, 2010.
6. Rodney Tolley, Editor, Sustainable Transport: Planning for walking and cycling in urban environments; Elsevier, 2003.

B. E-Learning and Web References:

1. https://www.e-education.psu.edu/eme807/node/532

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CE5618: TRAFFIC CONTROL AND MANAGEMENT

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minor	Mid exam	End exam	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

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

CO1: Develop the schemes and policies for efficient traffic control.
CO2: Design traffic control measures for all type of roads.
CO3: Evaluate traffic control system alternatives for urban/rural roadways.
CO4: Develop and apply traffic control and management strategies at local and regional level road network.

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Detailed Syllabus **Hours**

1. Traffic control concepts and regulations: **10**

Traffic control and its necessity, concepts, types, emerging technologies, benefits, strategies, legislation and laws, motor vehicle act, traffic control warrants, traffic control aids and road signs and need for signals control, placement of signs, practice with examples.

2. Speed Control measures: **10**

Free speed and speed limits, calming devises, speed control strategies, community awareness and education, speed enforcements, signs for speed control, statistical analysis of speed control strategies, case studies.

3. Urban and interurban traffic control: **12**

Control variables, roadway congestion and work zones/incident traffic controls studies, ramp controlled highways, Warrant analysis for uncontrolled and signalized intersection, basic signal design, signal coordination, bicycle and pedestrian considerations, vulnerable and disable road users, measure of effectiveness, access control, practice with examples and case studies.

4. Traffic management and strategies **10**

Traffic system and management centers, communication and information systems, methods of information disseminations, traffic segregation, diversions and one-way street, integrated traffic management, ITS strategies, case studies. Local level traffic planning and management, residential neighborhoods, street lighting equipment, maintenance and installation issues land use developments and traffic system, computer applications and traffic simulation, case studies.

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. Hamada Alshaer, Demanding Traffic Control and Management in Next Generation Networks, Lap Lambert Academic Publishing, 2010.
2. Hawkins, H.G., Guidelines for Conducting a Traffic Signal Warrant Analysis, 2nd edition, Texas Transportation Institute, 2008.
3. Manual on uniform traffic control Devices for streets and highways, USDT, Federal highway administration, 2009.
4. Nicholas J. Garber and Lester A. Hoel, Traffic and Highway Engineering, 5th edition (SI), Cengage Learning, Reprint 2017.
5. Roger P. Roess, Elena S. Prassas and William R. McShane, Traffic Engineering, Fifth Edition, Pearson, 2019.

B. E-Learning and Web References:

1. https://nptel.ac.in/courses/105101008/#
2. https://ops.fhwa.dot.gov/publications/fhwahop08024/chapter5.htm#5.1
3. https://static.tti.tamu.edu/tti.tamu.edu/documents/0-4701-P2.pdf

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CE5620: TRANSPORT POLICY AND FINANCING

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

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

CO1: Appreciate the issues related to transportation policy and the role of engineers and planners in transportation policy making.
CO2: Analyze issues in National Transportation Policy
CO3: Appreciate and analyse implications of National Transport Development Policy and National Urban Transport Policy
CO4: Differentiate various current methods of transportation funding in India.
CO5: Explore the role of private parties in transportation financing.

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):						
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	3	3	1	1
CO2	2	2	3	3	1	1
CO3	2	2	3	3	1	1
CO4	2	2	3	3	1	1
CO5	2	2	3	3	1	1

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Issues in Transport Policy **6**

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.

2. National Transport Development Policy **6**

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

3. National Urban Transport Policy **6**

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.

4. Five Year Plans – Transportation Policy **4**

About five year plans, Transportation policy changes in the five year plans.

5. Various Acts Related to Transport **4**

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

6. Investment Policies and Pricing **4**

Traditional cost-benefit analysis, increased competition created by improved transport, Reduction of transport barriers.

7. Role of Private Participation **6**

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.

8. Transport Financing **6**

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

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. Commission of the European Communities, Institution of Civil Engineers, Highway Investment in Developing Countries, Thomas Telford Ltd., 1983.
2. Dai Nakagawa and Ryoji Matsunaka, Transport Policy and Funding, Elsevier, Oxford, UK, 2006
3. David Banister and Joseph Berechman, Transport Investment and Economic Development, UCL Press, London, 2000
4. Kenneth A. Small and Erik T. Verhoef, Urban Transportation Economics, 2nd Edition, Routledge, London, 2006.
5. National Transport Development Policy Documents, Government of India, New Delhi, 2012.
6. National Urban Transport Policy, Ministry of Urban Development, Government of India, New Delhi, 2006 and 2014.
7. Various National Acts on Transport.

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CE5621: TRANSPORTATION DATA ANALYSIS

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

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

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

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):						
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	3	1		
CO2	3	1	3	1		
CO3	3	1	3	1		
CO4	3	1	3	1		
CO5	3	1	3	1		

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Data Description and Presentation **5**

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

2. Probability Laws and Distributions **8**

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 Hypergeometric distribution, applications in transportation engineering.

3. Statistical Inference and Tests of Significance **7**

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.

4. Sampling Techniques **4**

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.

5. Regression and Correlation **6**

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.

6. Parameter Estimation and Curve Fitting Techniques **6**

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

7. Time Series Forecasting **6**

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

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. Alfredo H.S. Ang and Wilson H. Tang, Probability Concepts in Engineering Planning and Design, Volume I & II, John Wiley & Sons, Singapore, 2007
2. Blank L., *Statistical procedures for engineering, management, and science*. McGraw Hill, Book, London, 1990.
3. Bovas A., Nair N. U., *Quality improvement through statistical method,* Springer Science &Business Media, 1998.
4. F.D. Hobbs, Traffic Planning and Engineering, 2nd Edition, Elsevier, 1979
5. Joseph F. Hair, William C. Black, Barry J. Babin and R. Anderson E.*, Multivariate data analysis*, 7th Edition, Prentice Hall, 2010
6. P.N. Arora, S. Arora, Arora A., *Elements of statistical method*, S. Chand & Company LTD., New Delhi, 2009.
7. Richard Haberman, *Mathematical Models*, 1st Edition, Society for Industrial and Applied Mathematics, 1999.
8. Robert V. Hogg, and Elliot Tanis and Dale Zimmerman, *Probability and Statistical Inference*, 9th Edition, Pearson, 2014
9. Simon P. Washington, Matthew G. Karlaftis, Fred L Mannering, *Statistical and econometric methods for transportation data analysis*, Second Edition, CRC Press, 2010.

B. E-Learning and Web References:

1. http://courses.washington.edu/cee412/
2. https://ocw.mit.edu/courses/mathematics/18-05-introduction-to-probability-and-statistics-spring-2014/

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CE5622: WATERWAY INFRASTRUCTURE PLANNING AND DESIGN

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

Course Outcomes (COs): At the end of the course, students will be able to	
CO1:	Plan and design harbour facilities.
CO2:	Estimate Traffic demand for harbour planning.
CO3:	Discriminate harbour works, berthing structures and transit sheds.
CO4:	Distinguish repair facilities for port and cargo handling facilities.
CO5:	Design coastal protection facilities.
CO6:	Plan navigational aids and inland navigation for safe operations.

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):						
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	1	3	3	2
CO2	1	2	3	3	3	2
CO3	2	2	3	1	2	2
CO4	3	2	3	2	2	3
CO5	3	2	2	3	2	2

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Harbour Planning **8**

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

2. Harbour Structures and Navigational Aids **6**

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

3. Docks and Locks **6**

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

4. Port Facilities **8**

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

5. Dredging and Coastal Protection **8**

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

6. Inland Navigation **6**

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

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. Adrian Jarvis, Ports and harbour Engineering, Studies in the history of civil engineering, 1998
2. Bindra, S.P.A Course in Docks and Harbour Engineering, Dhanpat Rai and Sons, New Delhi, India, 1992.
3. Brysson Cunningham, The dock and harbour engineer's reference book, Second Edition, 2011.
4. Seetharaman, S. Dock and Harbour Engineering, Umesh Publications, New Delhi, India, 1999.
5. Venkatramaiah, Transportation Engineering, Vol. 2: Railways, Airports, Docks and Harbours, Bridges and Tunnels, June 2017

B. E-Learning and Web References:

1. https://www.youtube.com/watch?v=gT0rAkmNuD8

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M.Tech (Transportation Engineering) II Semester

CE5651: PUBLIC TRANSPORTATION SYSTEMS

Course Type	Theory Course – Core			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	CE5601: Urban Transportation Planning			

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

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

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Transit Systems **6**

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.

2. Estimation of Transit Demand **6**

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

3. Bus Route Network Planning **6**

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.

4. Bus Scheduling **6**

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

5. Mass Transit Corridor Identification & Planning **6**

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.

6. Public Transport Management Measures **6**

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

7. Transit Terminals and Performance Evaluation **6**

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

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. Alan Black, Urban Mass Transportation Planning, McGraw-Hill International Enterprises, Inc. 1995.
2. David A. Hensher, Bus Transport: Economics, Policy and Planning. Research in Transportation Economics Volume 18. Elsevier Publications, 2007.
3. George E. Gray and Lester A. Hoel: Public Transportation: Planning, Operation and Management, 2nd Edition, Prentice Hall; 1992
4. Michael D. Meyer, Transportation Planning Handbook, Fourth Edition, Institute of Transportation Engineers, John Wiley & Sons Inc., 2016
5. Nick Tyler, Accessibility and the Bus System: from Concepts to Practice, Thomas Telford, 2002.
6. P.R. White, Public Transport: Its Planning, Management and Operation, Fifth Edition, London New York, 2008.
7. Simpson, Barry J., Urban Public Transport Today. Taylor & Francis Routledge Publisher, 2003
8. Tiwari G., Urban Transport for Growing Cities: High Capacity Bus System, MacMillan India Ltd., 2002
9. Vukan R. Vuchic, Urban Transit: Operations, Planning and Economics, Wiley, 2005.

B. E-Learning and Web References:

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

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CE5652: Geometric Design of Highways and Streets

Course Type	Theory Course – Core			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minor	Mid exam	End exam	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	CE5602: Traffic Analysis			

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

CO1: Carry out geometric design of uninterrupted flow facilities.
CO2: Design and evaluate un-signalized and signalized intersections for given traffic conditions.
CO3: Design and evaluate bicycle and pedestriantraffic facilities.
CO4: Design parking layouts and street lighting for streets and highways.

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Geometric design of uninterrupted roadway facility: **9**

Elements of geometric design, cross sectional elements, sight distance considerations, factor affecting geometric design, highway alignments and topography, design controls and criteria, mobility and accessibility, landscaping of roadways, design and evaluate multilane highways, expressways design requirements, weaving segments analysis, auxiliary lanes, ramp roadways, practice with examples.

2. Design of At-grade and grade separated intersections: **12**

Types of at-grade intersections, factors affecting design, intersection traffic control, conflict points, uncontrolled intercession analysis, capacity of rotary, analysis of roundabouts, warrants for signalization, design of signalized intersection, saturation flow rate and capacity, design of all aspects of signal timings, analysis of delay and queue length level-of-service analysis, signal coordination, channelizing devices, design guidelines, Necessities of interchanges, classification and types of common interchanges, interchange warrants, design elements, delay analysis for interchange, problem solving examples.

3. Design of Bicycle and Pedestrians Flow Facilities: **9**

Bicycle flow characteristics, performance measures, bikeway capacity, interrupted and uninterrupted bicycle flow facility, shared off-street and on-street facilities, evaluation of urban street for bicycle path, control delay and LOS analysis.

Pedestrian flow characteristics, pedestrian space requirements, performance measures, factor affecting pedestrian demand, demand analysis, design and evaluation of pedestrian facility at intersections, sidewalk and crosswalk design, street corner analysis, pedestrian signals, and design examples.

4. Design of Parking Facilities: **6**

Parking types, factor influencing parking demand, parking angles and aisle, on-street parking requirement, design parameters, parking surveys and demand analysis, various parking layouts and vehicle circulation, evaluation of off-street parking facilities, design examples.

5. Design of Street lighting system: **6**

Definitions, pavement luminance and its measurement, illumination level, Veiling Luminance, horizontal and vertical luminance longitudinal uniformity, utilization factor, depreciation factor, maintenance factor, and practice with examples.

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. C. Jotin Khisty and B. Kent Lall, Transportation Engineering: An Introduction, 3rd Edition, Pearson, 2016
2. Fred L. Mannering, Scott S. Washburn, Kilareski Walter P., Principles Of Highway Engineering and Traffic Analysis, 4th Edition, Wiley India Pvt Ltd., 2011.
3. Highway Capacity Manual 2010, Transportation Research Record, Transportation Research Board, Washington, D.C., 2010
4. Indian Highway Capacity Manual (Indo HCM), CSIR-CRRI, New Delhi, 2017.
5. L.R. Kadiyali, Traffic Engineering and Transportation Planning, Khanna Publishers, 2012.
6. Nicholas J. Garber and Lester A. Hoel, Traffic and Highway Engineering, 5th edition (SI), Cengage Learning, Reprint 2017.
7. Roger P. Roess, Elena S. Prassas and William R. McShane, Traffic Engineering, Fifth Edition, Pearson, 2019.

B. E-Learning and Web References:

1. https://nptel.ac.in/courses/105101087/downloads/Lec-15.pdf
2. https://nptel.ac.in/courses/105101087/downloads/Lec-18.pdf
3. https://nptel.ac.in/courses/105101087/downloads/Lec-11.pdf

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CE5653: PAVEMENT CONSTRUCTION AND EVALAUTION

Course Type	Theory Course – Core			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	CE5603: Pavement Analysis and Design			

Course Outcomes (COs): At the end of the course, students will be able to	
CO1:	Select appropriate earth moving and compaction equipment depending upon the requirement.
CO2:	Prepare quality assurance and quality control plans in an attempt to construct better performing pavements.
CO3:	Evaluate the pavements based on the functional and structural characteristics.
CO4:	Evaluate the safety aspects of the pavements specifically in terms of friction and other related distresses.
CO5:	Select maintenance technique depending upon the intensity of the distresses.

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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
CO5	1	1	2	2	3	1

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Highway Construction Equipment **2**

Applications and safety aspects of earth moving equipment, compaction equipment, road making equipment, concreting equipment and paving equipment.

2. Pavement Construction **10**

Construction and preparation of subgrade soil, construction of sub-base layer, construction of base layer, construction of bituminous surface layers, construction of cement concrete surface layer and MoRTH specifications.

3. Functional Evaluation of Pavements **12**

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

4. Structural Evaluation of pavements **12**

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

5. Pavement Maintenance **6**

Routine maintenance, periodic maintenance, special repairs, responsive maintenance programme, rehabilitation and reconstruction, treatment strategies and selection.

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. Croney, D. and P. Croney, The design and performance of road pavements, McGraw-Hill Book Company, London, UK, 1991.
2. Haas, R., W.R. Hudson and J.P. Zaniewski, Modern Pavement Management, Krieger Publishing Company, Malabar, Florida, USA, 1994.
3. Huang, Y.H. Pavement Analysis and Design, Second Edition, Dorling Kindersley (India) Pvt. Ltd., New Delhi, India, 2008.
4. Mallick, R.B. and T. El-Korchi, Pavement Engineering – Principles and Practice, CRC Press, Taylor and Francis Group, Florida, USA, 2009.
5. Ministry of Road Transport and Highways, Specifications for Road and Bridge Works, Fifth Edition, Indian Roads Congress, New Delhi, India, 2013.
6. P.S Kandhal, Bituminous Road Construction India, Revised Edition, December 2017.
7. Papagiannakis, A.T. and E.A. Masad, Pavement Design and Materials, John Wiley and Sons, New Jersey, USA, 2008.
8. Relevant Indian Road Congress codes, Bureau of Indian Standards and International standards such as ASTM and AASHTO.
9. Shahin, M.Y. Pavement Management for Airports, Roads, and Parking Lots, Third Edition, Kluwer Academic Publisher, Massachusetts, USA, 2005.

B. E-Learning and Web References:

1. https://www.pavementinteractive.org/
2. https://www.appliedpavement.com/pavement-evaluation-and-design.html

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CE5654: PAVEMENT MATERIALS AND EVALUATION LABORATORY

Course Type	Laboratory			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	0	1	2	2
Evaluation:	Cont. Evaluation	Lab Skill	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

Course Outcomes (COs): At the end of the course, students will be able to	
CO1:	Characterize the pavement materials including soil, aggregate, bitumen, and bituminous mixes in the laboratory.
CO2:	Perform quality control tests on pavements and pavement materials.
CO3:	Evaluate the functional response characteristics of in-service pavements
CO4:	Evaluate the structural response characteristics of in-service pavements.

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):						
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	1	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
CO5	1	1	3	2	3	2

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus

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

Learning Resources:

A. Readings and References:

1. Central Materials Laboratory Testing Manual, 2000, the United Republic of Tanzania, Ministry of Works.
2. Huang, Y.H. Pavement Analysis and Design, Second Edition, Dorling Kindersley (India) Pvt. Ltd., New Delhi, India, 2008.
3. S.K. Khanna, C.E.G. Justo, and A. Veeraragavan, *Highway Materials and Pavement Testing*, 5th Edition, Nem Chand and Bros, Roorkee, India, 2009.
4. Relevant IS, IRC, ASTM Codes.

B. E-Learning and Web References:

1. https://www.youtube.com/watch?v=UWmAabRxR6w

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CE5655: TRANSPORTATION ENGINEERING SOFTWARE LABORATORY

Course Type	Practical Course – Core			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	0	1	2	2
Evaluation:	Report	Written Test	Practical	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

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

CO1: Estimate Travel Demand using relevant transportation planning packages.
CO2: Design isolated and coordinated traffic signals using standard tools.
CO3: Analyze Flexible and Rigid Pavements relevant software.
CO4: Simulate traffic at mid-block as well as at Intersections using microscopic simulation tools.

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus

TRANSPORTATION PLANNING PACKAGES:

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

TRAFFIC ENGINEERING PACKAGES:

MXRoad
VISSIM
SIDRA
SUMO
VISWALK
VISTRO
VISUM Safety
VISWALK

PAVEMENT EVALUATION & ECONOMIC ANALYSIS PACKAGES:

Ken-layer & Ken-slab
HDM – IV

Exercises on Usages of the Packages and Mini-Project:

Learning Resources:

A. Readings and References:

1. User Manuals of various packages.

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CE5691: SEMINAR – II

Course Type	Seminar – Core			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	0	0	2	1
Evaluation:	Weekly Reviews		End Sem.	Grading
Continuous	50%		50%	Relative
Pre Requisite Courses	Nil			

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

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

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus

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

Learning Resources:

A. Readings and References:

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

B. E-Learning and Web References:

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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CE5661: ADVANCED TRAVEL DEMAND MODELLING

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	CE5601:Urban Transportation Planning			

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

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

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Discrete Choice Analysis **8**

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.

2. Stated Preference Methods **6**

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

3. Activity Based Travel Demand Models **6**

Activity patterns; Activity scheduling; Activity Time Allocation studies; Activity Episode Analysis; Travel Duration Analysis

4. Qualitative Variables **6**

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

5. Model Aggregation and Model Transferability **5**

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.

6. Simplified Travel Demand Models **5**

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

7. Introduction to Advanced Modeling Techniques **6**

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.

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. Alan Geoffrey Wilson. Optimisation in Location and Transport Analysis, John Wiley & Sons, 1981 (Digitized: 31 March 2011).
2. Harry Timmermans, *Progress in Activity Based Analysis*, Elsevier Science, 2005.
3. Joe Castiglione, Mark Bradley and John Gliebe, Activity-Based Travel Demand Models: A Primer, TRB, Washington, D.C., 2015
4. Juan de Dios Ortuzar and Luis G. Willumsen, *Modelling Transport, 4th Edition*, John Wiley and Sons, 2011.
5. Laurie A. Garrow, Discrete Choice Modelling and Air Travel Demand: Theory and Applications, Routledge, 2010
6. Moshe Ben-Akiva, and Steven R. Lerman, *Discrete Choice Analysis: Theory and Application to Travel Demand*, The MIT Press, Paperback 2018.
7. Norbert Oppenheim, *Urban Travel Demand Modelling: From Individual Choices to general Equilibrium*, John Wiley and Sons, Inc., 1995 (Digitized 29 June 2011).
8. Time use Analysis, Special Issue, Transportation, 26, Kluwer Academic Publishers, 1999.

B. E-Learning and Web References:

1. https://professional.mit.edu/programs/short-programs/discrete-choice-analysis
2. http://support.sas.com/techsup/technote/mr2010f.pdf
3. https://eml.berkeley.edu/books/train1201.pdf
4. https://ocw.tudelft.nl/courses/transportation-and-spatial-modelling/

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CE5662: GIS FOR TRANSPORTATION

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

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

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

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. GIS Concepts and Data Models **8**

Geospatial data, Sources, Methods of collection, Evolution of Digital Mapping, Attribute Data, Data formats and Collection methods, Introduction and Concepts of GIS.Data Domains and Data Modelling in GIS – T; Data Modelling Techniques; Networking in Transportation System; Linear referencing methods and systems; Transportation Data Models for ITS and related Applications..

2. Transportation Data Sources and Integration **6**

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

3. Shortest Path and Routing **4**

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

4. Network Flows and Facility Location **6**

Flow through Uncongested Networks; Flow through Congested Network; Facility location within Networks; Spatial Aggregation in Network Routing and location problems.

5. GIS Based Spatial Analysis and Modelling **6**

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

6. Transportation Planning **6**

Transportation Analysis Zone Design; Travel demand Analysis; Land use – Transportation Modelling; Route Planning; Decision support for Transportation Planning, Intelligent Transportation Systems.

7. Transportation, Environment and Hazards **6**

Mapping sensitive Environmental features; GIS and Transportation related Air Quality; Accidents and Safety Analysis; Transportation of hazardous Materials.

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. Alan Paul Vonderohe, Alan Travis, and Robert Smith. Implementation of Geographic Information Systems (GIS) in State DOTs: An NCHRP Digest of the Essential Findings from the Interim Report on NCHRP Project 20-27 'Adaptation of Geographic Information Systems for Transportation', *Issue 180 of Research results digest*, TRB, 1991.
2. Chor Pang Lo, Albert K.W. Yeung - *Concepts and Techniques of Geographic Information Systems*, 2nd Edition, Prentice Hall, 2006.
3. Henk J. Scholten and John Stillwell, Geographical Information Systems for Urban and Regional Planning, Springer, 2010.
4. Miller HJ and Shaw SL, Geographic Information Systems for Transportation (GIS – T): Principles and Applications, Oxford University Press, 2001
5. NCHRP Synthesis 446. Use of Advanced Geospatial Data, Tools, Technologies, and Information in Department of Transportation Projects: A Synthesis of Highway Practice, TRB 2013.
6. Simlowitz HJ. GIS Support Transportation System Planning, International GIS Sources Book
7. TCRP Synthesis 55. Geographic Information Systems Applications in Transit: A Synthesis of Transit Practice, TRB, 2004.
8. Thill JC, GIS in Transportation, Transportation Research Part C, 2000.

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CE5663: INTELLIGENT TRANSPORTATION SYSTEMS

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

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

CO1: Differentiate ITS user services and its components.
CO2: Determine the suitable ITS technology and assess its effectiveness to solve transportation problems.
CO3: Analyze data collected using various detection methods and formulate methodologies to disseminate the information for various applications.
CO4: Design and implement the suitable ITS solutions for safe and sustainable transportation.

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. ITS Background and Telemetric systems **4**

Definitions, features and objectives of ITS, History of ITS and its development over the world, ITS taxonomy, ITS application areas, uses, and application overview.

2. ITS User Services **8**

Infrastructure based services; Arterial management and integration, freeway/highway management, crash prevention and safety, roadway operation and maintenance, transit management, emergency management, Electronic payment and pricing, traveler information, Commercial Vehicle Operations, etc., Intelligent vehicle based services; collision notification and avoidance system, driver assistance system, and examples.

3. ITS components, tools and strategies **10**

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.

4. Design and implementation **12**

Design components; data acquisition methods, equipment and used technology, radar and sensor, detectors, vehicle identifiers, and GPS, Communication tools; DSRC, Worldwide ITS implementation and challenges, case studies.

5. ITS Standards **8**

ITS standards, development process, legal issues, financial issues, Mainstreaming ITS; Integration and up gradation; Future of ITS, case studies.

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. Chowdhury, M. A. and Sadek, A, Fundamentals of Intelligent Transportation Systems Planning, Artech House, 2003.
2. IET Intelligent Transport Systems and 15th International IEEE Conference on Intelligent Transportation Systems (ITSC), 16-19 September, 2012. (http://digital-library.theiet.org/content/journals/iet-its)
3. J.M. Sussman, *Perspectives on Intelligent Transportation Systems* (ITS), Springer, 2005
4. Pradip Kumar Sarkar and Amit Kumar Jain (2018), Intelligent Transportation Systems, PHI learning Private Limited, New Delhi.
5. R. Stough, Intelligent Transport Systems: Cases and Policies, Edward Elgar, 2001, Artificial Intelligence and Intelligent Transportation Systems, National Academy Press, 2010.

B. E-Learning and Web References:

1. Joseph Sussman. *1.212J An Introduction to Intelligent Transportation Systems.* Spring 2005. Massachusetts Institute of Technology: MIT OpenCourseWare, https://ocw.mit.edu. License: CreativeCommons BY-NC-SA.

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CE5664: LAND USE AND TRANSPORTATION PLANNING

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

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

CO1: Differentiate different urban forms and urban structures
CO2: Appreciate compact and smart city principles
CO3: Develop different land use models
CO4: Develop transit oriented development plans for a city
CO5: Develop land use and transportation models

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):						
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	3	3	1	2
CO2	3	2	3	3	1	2
CO3	3	1	3	3	1	1
CO4	3	1	3	3	1	2
CO5	3	1	3	3	1	2

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Urban Forms and Structures **8**

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

2. Compact Cities – Smart Cities **6**

Urban Planning Approach: Green city, Compact City, Smart City, City Typology

3. Land Use Planning **8**

Concentric urban land use model, Sector land use model, multiple nuclei land use model, hybrid land use models, Cellular automata models, and land rent theory; Urban regions.

4. Transit Oriented Development **8**

Transit Oriented Development: Characteristics, Components, Benefits; Policy and Guidelines, TOD Typology, Implementation Strategies, Challenges, Development and Control Norms

5. Land use – Transportation Models **12**

Land use – Transportation Interactions; Classification of LUT Models, Economic Base Mechanism, Allocation Mechanism and Spatial Allocation and Employment Relationships, Garin Lowry Models

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. C. Jotin Khisty and B. Kent Lall, Transportation Engineering: An Introduction, 3rd Edition, Pearson, 2016.
2. C.B. Schoeman, Land Use Management and Transportation Planning, WIT Press, 2015
3. C.S. Papacostas and P.D. Prevedouros, Transportation Engineering and Planning, Third Edition, Prentice Hall of India Pvt. Ltd., 2015.
4. Juan de Dios Ortuzar and Luis G. Willumsen, *Modelling Transport, 4th Edition*, John Wiley and Sons, 2011.
5. Michael D. Meyer, Transportation Planning Handbook, Fourth Edition, Institute of Transportation Engineers, John Wiley & Sons Inc., 2016
6. Stephen Marshall and David Banister, Land Use and Transport: European Research Towards Integrated Policies, Emerald Publishing, 2007

B. E-Learning and Web References:

1. https://ocw.tudelft.nl/courses/transportation-and-spatial-modelling/
2. http://mohua.gov.in/upload/uploadfiles/files/URDPFI%20Guidelines%20Vol%20I(2).pdf
3. https://www.sutp.org/files/contents/documents/resources/A_Sourcebook/SB2_Land-Use-Planning-and-Demand-Management/GIZ_SUTP_SB2a-Land-use-Planning-and-Urban-Transport_EN.pdf

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CE5665: PAVEMENT MANAGEMENT SYSTEM

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	CE5603: Pavement Analysis and Design			

Course Outcomes (COs): At the end of the course, students will be able to	
CO1:	Identify and select suitable design strategies for a given pavement
CO2:	Determine the pavement condition for various maintenance treatments
CO3:	Decide the type and timing of maintenance required for given pavement
CO4:	Evaluate and estimate the life cycle cost of pavements.

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Introduction to Pavement Management System **8**

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

2. Pavement Performance Models **10**

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

3. Alternative Design Strategies **10**

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

4. Pavement Prioritization Techniques **10**

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

5. Implementation of PMS and Technologies **4**

Major steps in Implementation of PMS, operational Issues, system complexity, feedback, other Institutional Issues and PMS case studies, Network survey vehicle , remote sensing and spatial technologies in PMS.

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. Advanced Course on Pavement Management, Course Notebook, Federal Highway Administration, Washington, D.C., 1990.
2. Haas, R., W. R. Hudson, and J. P. Zaniewski. Modern Pavement Management. Krieger Publishing Company. Malabar, Florida, 1994.
3. Hudson, W. R., R. Haas and W. Uddin. Infrastructure Management: Integrating Design, Construction, Maintenance, Rehabilitation, and Renovation. McGraw Hill. New York, 1997.
4. Ralph C.G. Haas and W. Ronald Hudson, Pavement Management System, McGraw-Hill Inc. 1978.
5. Ralph Haas, W. Ronald Hudson and John P. Zanieswki. Modern Pavement Management, Kreiger Publishing Company, 1994.
6. Shahin, M.Y. Pavement Management for Airports, Roads, and Parking Lots, Third Edition, Kluwer Academic Publisher, Massachusetts, USA, 2005.
7. Wisconsin Department of Transportation, Pavement Management Decision Support Using A Geographic Information System; FHWA (Report No. FHWADP-90-085-006); Washington DC; 1990.

B. E-Learning and Web References:

1. https://nptel.ac.in/courses/105106115/26

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CE5666: ROAD ASSET MANAGEMENT

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

Course Outcomes (COs): At the end of the course, students will be able to	
CO1:	Value the principles and concepts of asset management.
CO2:	Develop Highway Inventory systems.
CO3:	Develop Financial Management and workforce management systems
CO4:	Develop Construction Management and Safety Management Systems.
CO5:	Develop Bridge Management System.
CO6:	Develop Pavement Management & Highway Maintenance Management Systems.

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Detailed Syllabus **Hours**

1. Highway Asset Management **10**

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

2. Highway Asset Valuation and Frame Work **8**

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

3. Construction Management Systems **8**

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

4. Roadway Operations Management Systems **8**

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

5. Road Asset Management Modules **7**

Bridge inventory and rating, bridge management

Workforce Management Systems

Payroll detail, personal information and employee accident.

Safety Management Systems

Accident records, hazardous location and highway safety information

Equipment Management Systems

Equipment management information, fleet management

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

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

B. E-Learning and Web References:

1. https://www.youtube.com/watch?v=ep3j7f__LuM

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CE5667: ROAD SAFETY ENGINEERING

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

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

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

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Road Safety Trends and Factors **4**

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

2. Statistical Interpretation and Crash Data Analysis **6**

Before-after methods in crash analysis, Recording of crash data; Accident Investigation and Analysis; Statistical testing and the role of chance; Black Spot Identification Methods and Investigations: Multiple linear and logistic methods, GIS based identification, Artificial intelligence and machine learning in black spot identifications, Case Studies.

3. Road Safety Audits **10**

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, Relevant IRC and IRF practices.

4. Road Safety Management System **6**

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

5. Crash Reconstruction **8**

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, Poisson impact and Kinetic energy theory, Case Studies.

6. Mitigation Measures **8**

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

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. Geetam Tiwari and Dinesh Mohan, Transport Planning and Traffic Safety: Making Cities, Roads, and Vehicles Safer, CRC Press, 2016.
2. Institute of Transportation Engineers (ITE), The Traffic Safety Toolbox: A Primer on Traffic Safety, ITE, 1999.
3. IRC: SP:44-1996: Highway Safety Code, The Indian Roads Congress, New Delhi, 1996.
4. IRC: SP-88-2010: Road Safety Audit Manual, The Indian Roads Congress, New Delhi, 2010.
5. IRC:SP: 55-2014: Guidelines on Traffic Management in Work Zones, The Indian Roads Congress, New Delhi, 2014
6. J. Stannard Baker, Traffic Collision Investigation, Northwestern University Center for Public Safety, 2002.
7. Road Traffic and Work Zone Safety Manual, National Highway Authority of India, 2012.
8. Rune Elvik and TrulsVaa, The Handbook of Road Safety Measures, Elsevier, 2004.

B. E-Learning and Web References:

1. http://www.rsatoolkit.com.au
2. http://www.sutpindia.com/skin/pdf/Toolkits/Urban%20Road%20Safety%20Audit_200614.pdf
3. https://www.who.int/violence_injury_prevention/road_traffic/activities/training_manuals/en/
4. https://roadsafetyatwork.jibc.ca/courses/investigating-motor-vehicle-incidents/

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CE5668: TRAFFIC FLOW MODELLING AND SIMULATION

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	CE5602: Traffic Analysis			

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

CO1: Develop traffic stream models.
CO2: Analyse and develop Pedestrian stream models
CO3: Analyse shockwaves.
CO4: Analyse traffic queuing systems.
CO5: Simulate traffic at mid blocks and intersections.

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Traffic Flow Modeling **10**

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

2. Pedestrian Flow Modeling **4**

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

3. Shockwave Analysis **6**

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

4. Queuing Analysis **6**

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

5. Simulation Methodologies **8**

Random number generation; Simulation methods; Fundamentals of simulation, Components of traffic simulations models, vehicle arrival and movement models, mixed traffic flow simulation, Simulation model development strategies; Study of large scale simulation models; Time based and Even-based methods; Examples of Macro, Meso, and Microscopic based simulation models.

6. Calibration and Validation of Simulation Models **8**

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

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. Banks, J; Carson, JS; Nelson, B.L. Discrete-event system simulation. 5th Edition, Upper Saddle River, NJ: Prentice-Hall, 2010.
2. Barceló, J. "Models, Traffic Models, Simulation, and Traffic Simulation". Barceló, J. ed. Fundamentals of traffic simulation. New York: Springer, 2010.
3. Fred L. Mannering, Scott S. Washburn, Kilareski Walter P., Principles Of Highway Engineering And Traffic Analysis, 4th Edition, Wiley India Pvt Ltd., 2011.
4. Highway Capacity Manual 2010, Transportation Research Record, Transportation Research Board, Washington, D.C., 2010
5. May, A.D. Traffic Flow Fundamentals, 1st Edition, Prentice Hall, 1990.
6. Roger P. Roess, Elena S. Prassas and William R. McShane, Traffic Engineering, Fifth Edition, Pearson, 2019.

B. E-Learning and Web References:

1. https://nptel.ac.in/downloads/105101008/

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CE5669: TRANSPORT ECONOMICS AND PROJECT APPRAISAL

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

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

CO1: Differentiate macro and micro economic principles
CO2: Quantify benefits and costs of transport projects and carryout economic analysis
CO3: Evaluate transport projects
CO4: Analyse life cycle cost of a transport projects
CO5: Appreciate private sector participation in transportation industry

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Transport Economics **6**

Review of Engineering Economics and Microeconomics, Welfare Theory and Equilibrium Conditions, Goals and Objectives, Principles of Economic Analysis

2. Methods of Economic Analysis **8**

Discounted Cash Flows: Analysis of User Costs and Benefits, RUCS Models for Costs and Benefits, Methods of Economic Analysis; Suitability, Analysis for Null Alternative

3. System Selection and Evaluation **12**

Framework of Evaluation, Transport Planning Evaluation at Urban and Regional levels, Other Evaluation Procedures - Traditional Economic Analysis, Achievement Matrices, Factor Profiles, Plan Ranking, Introduction to Mathematical Programming, Bidding Games, Delhi Technique, Multi-Criteria Evaluation, Case Studies.

4. Life Cycle Cost Analysis **6**

Factors consider for Life Cycle Cost Analysis; Data requirements for highway project feasibility analysis, establishment of Technical/ Economic/ Financial feasibility of a highway project, Social Benefits, Role of HDM in feasibility studies.

5. Project Appraisal – Private Sector Participation **10**

BOT, BOOT, BOLT Projects – Case history – Project Planning – Project System Management – Project Implementation – Funds Planning – Budgetary and Control – Tendering and Contract – Value Analysis, Information System - Impact assessment, Project Report Preparation.

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. C.G. Swaminathan and L.R. Kadiyali, Road User Cost Study in India, Central Road Research Institute, New Delhi, 1983.
2. CRRI, Updation of Road User Study Data and Road User Costs, CRRI, 2012
3. Highway investment in Developing countries; Commission of the European Communities, Institute of Civil Engineers, Thomas Telford Ltd 1983.
4. John W. Dickey and Leon H. Miller, Road Project Appraisal for Developing countries, John Wiley and Sons., 1984.
5. L.R. Kadiyali, Traffic Engineering and Transport Planning, Khanna Publishers, 2012.
6. Michael J Markow, Engineering Economic Analysis Practices for Highway Investment, NCHRP Synthesis 424, TRB, 2012
7. Robley Winfrey, Economic Analysis for Highways - International Text Book Co., Pennsylvania, 1969.
8. Vinay Maitri and P.K Sarkar, Thory and Applications of Economics in Highway and Transport Planning, Standard Publishers Distributors, First Edition 2010.

B. E-Learning and Web References:

1. https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-201j-transportation-systems-analysis-demand-and-economics-fall-2008/

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CE5670: TRANSPORTATION LOGISTICS

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	Nil			

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

CO1: Appreciate logistic systems and city logistics.
CO2: Model demand and supply for logistic systems.
CO3: Apply mathematical programming in modelling city logistics.
CO4: Perform different methods of optimizing logistics in urban areas.
CO5: Suggest appropriate ITS tools in efficiently managing the logistics

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):						
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	3	3	1	2
CO2	3	1	3	3	1	1
CO3	3	1	3	3	1	2
CO4	3	1	3	3	1	2
CO5	2	1	1	3	1	2

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Mathematical Programming for City Logistics **10**

Modeling logistics; Demand and supply model; Mathematical programming; Inventory model, physical distribution networks, Linear programming; Non-linear programming; Application of linear and non-linear programming, vehicle routing.

2. Modelling Logistics **10**

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

3. Aggregated and Disaggregated Demand Forecast for City Logistics **8**

Aggregated demand forecast; Disaggregated demand forecast.

4. Logistics Optimisation **8**

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

5. Use of ITS in City Logistics **6**

Fundamental concepts, Data acquisition, data processing, information dissemination, geographic information systems, effects of e-commerce; Current ITS applications, evaluation issues

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. Alan McKinnon, Kenneth J. Button and Peter Nijkamp (Editors), Transport Logistics, Edward Elgar Publishing Ltd., 2002
2. Bramel, J., and Levi, D. S., The Logic of Logistics: Theory, Algorithms, and Application for Logistics Management, Springer-Verlag, New York, USA, 1997.
3. Lambert, M. D., Srock, J. R., and Ellram, M. L., Fundamentals of Logistics Management, McGraw Hill International Editions, 1998.
4. Michael B. Stroh, A Practical Guide to Transportation and Logistics, Third Edition, Logistics Network Inc., 2006
5. Taniguchi, E., Thompson, R. G., Yamada, T., and Duin, R. V., City Logistics – Network Modelling and Intelligent Transport Systems, Pergamon, 2001.

B. E-Learning and Web References:

1. Caplice, Chris, and Yossi Sheffi. *ESD.260J Logistics Systems, Fall 2006*. (MIT OpenCourseWare: Massachusetts Institute of Technology), http://ocw.mit.edu/courses/engineering-systems-division/esd-260j-logistics-systems-fall-2006 (Accessed 7 Jan, 2014). License: Creative Commons BY-NC-SA
2. Eurodecision, Operational research, Logistics Optimization. http://www.eurodecision.eu/logistics-optimization
3. https://www.pwc.com/gx/en/transportation-logistics/pdf/tl2030_vol.4_web.pdf

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CE5671: TRANSPORTATION NETWORKS AND OPTIMISATION

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	CE5601: Urban Transportation Planning			

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

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

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Transport Network Characteristics **6**

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

2. Optimality and Cost Functions **6**

Matrix operations, Objective functions, Traffic representation, Junctions costs, Priority junctions, Signal controlled junctions.

3. Assignment Techniques **8**

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.

4. Trip Table Estimation **6**

Maximum entropy, Generalized least squares, Linear path-flow estimations, Log-linear path-flow estimations, Time-dependent methods, Case Studies.

5. Network Reliability **6**

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

6. Network Design **10**

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

Total Instruction / Contact Hours **42**

Learning Resources:

A. Readings and References:

1. Ahuja R., T. Magnanti, and J. Orlin. Network Flows; Prentice Hall, 1993.
2. Michael Alexander Florian, Michel Gendreau, Patrice Marcotte. Transportation and network analysis: current trends: miscellanea in honor of Michael Florian; Springer Publisher, 2002.
3. Michael G.H. Bell and YasunoriLida. Transportation Network Analysis, J. Wiley Publishers, 1997.
4. Yosef Sheffi. Urban Transportation Networks: Equilibrium Analysis with Mathematical Programming Methods, Prentice Hall Publishers, 1985. (http://web.mit.edu/sheffi/www/selectedMedia/sheffi_urban_trans_networks.pdf)

B. E-Learning and Web References:

1. https://transportgeography.org/?page_id=623
2. https://www.e-education.psu.edu/geog597i_02/node/823

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CE5672: TRANSPORTATION SYSTEMS MANAGEMENT

Course Type	Theory Course – Elective			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	3	0	0	3
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	20%	30%	50%	Relative
Pre Requisite Courses	CE5601: Urban Transportation Planning CE5602: Traffic Analysis			

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

CO1: Develop appropriate TSM Actions for a given city
CO2: Develop suitable transit system management actions
CO3: Recommend methods to manage a transit system to improve its management efficiency.
CO4: Appreciate intricacies of traffic administration

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):						
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	3	3	3	2
CO2	3	2	3	3	3	2
CO3	3	2	3	3	3	2
CO4	1	2	2	2	1	2

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

1. Transportation System Management **16**

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

2. Transit System Management **8**

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

3. Transportation Demand Management **10**

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

4. Traffic Administration **8**

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

Total Instruction / Contact Hours **42**

Learning Resources:

C. Readings and References:

1. C. Jotin Khisty and B. Kent Lall, Transportation Engineering: An Introduction, 3rd Edition, Pearson, 2016
2. ITE, Transportation System Management and Operations: Action Kit – Immediate Solutions for Transportation Operational Issues, FHA, ITE, 2005
3. Michael D. Meyer, Transportation Planning Handbook, Fourth Edition, Institute of Transportation Engineers, John Wiley & Sons Inc., 2016
4. Program Committee for the Conference on Transportation System Management, et al. Transportation System Management, Special Report 172, Transportation Research Board.
5. Transportation System Management, State of the Art, UMTA, USDOT, 1977 (file:///C:/Users/Admin/Downloads/dot_680_DS1.pdf)

D. E-Learning and Web References:

1. https://ops.fhwa.dot.gov/publications/fhwahop17025/fhwahop17025.pdf

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M.Tech (Transportation Engineering), III Semester

CE6642: COMPREHENSIVE VIVA VOCE

Course Type	Comprehensive Viva Voce – Core			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	0	0	0	2
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	0%	0%	100%	Relative
Pre Requisite Courses	Both I & II Semester Course Work of I Year should be completed			

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

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

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

Entire course of study (all the required courses studied) up to II Semester of I Year

Total Instruction / Contact Hours **0**

Learning Resources:

A. Readings and References:

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

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CE6649: DISSERTATION PART – A

Course Type	Dissertation			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	0	0	0	9
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	0%	0%	100%	Relative
Pre Requisite Courses	Both I & II Semester Course Work of I Year should be completed			

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

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

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus **Hours**

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

Total Instruction / Contact Hours **0**

Learning Resources:

A. Readings and References:

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

B. E-Learning and Web References:

1. https://www.prospects.ac.uk/applying-for-university/university-life/how-to-write-a-dissertation
2. https://www2.le.ac.uk/offices/ld/resources/writing/writing-resources/planning-dissertation
3. http://onlinepubs.trb.org/onlinepubs/circulars/ec194.pdf

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M.Tech (Transportation Engineering), IV Semester

CE6699: DISSERTATION PART – B

Course Type	Dissertation			
Instructions:	Lecture	Tutorial	Practical	Credits
Hours/Week	0	0	0	18
Evaluation:	Minors	Mid Sem.	End Sem.	Grading
Continuous	0%	0%	100%	Relative
Pre Requisite Courses	Both I & II Semester Course Work of I Year should be completed CE6649: Dissertation Part – A			

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

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

Mapping of the Course Outcomes (COs) with Program Outcomes (POs):

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

Note: 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus

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

Learning Resources:

A. Readings and References:

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

B. E-Learning and Web References:

1. https://www.prospects.ac.uk/applying-for-university/university-life/how-to-write-a-dissertation
2. https://www2.le.ac.uk/offices/ld/resources/writing/writing-resources/planning-dissertation
3. http://onlinepubs.trb.org/onlinepubs/circulars/ec194.pdf

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