DEPARTMENT OF CIVIL ENGINEERING

ANNA UNIVERSITY, CHENNAI

OUR VISION:

Department of Civil Engineering, Anna University, shall strive hard to develop and impart technical knowledge and professional skills required for Civil Engineering practice through excellence in teaching, research and consultancy to address sustainable infrastructure development needs at local, national and International levels.

OUR MISSION:

Department of Civil Engineering, Anna University shall contribute to technological and social development by

1. Providing a firm scientific and technological base in Civil Engineering to achieve self- reliance.
2. Providing quality education through innovation in teaching practices at par with global standards.
3. Nurturing leadership and entrepreneurship qualities with ethical values.
4. Developing and disseminating the latest knowledge and technologies in emerging areas of Civil Engineering.
5. Sharing intellectual resources and infrastructure facilities through collaborative partnership.
6. Ensuring supporting conditions for enhancing employability skills.

ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

REGULATIONS – 2023

CHOICE BASED CREDIT SYSTEM

M. E. TRANSPORTATION ENGINEERING (FULL-TIME)

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

Graduates of the programme M E Transportation Engineering will

PEO1 Gain knowledge and skills in Traffic, Transportation Planning and Pavement engineering which will enable them to have a career and professional accomplishment in the public or private sector organizations

PEO2 To enable the students to have a strong analytical and practical knowledge of planning, designing and solving transportation problems.

PEO3 To introduce recent advancements in the fields of Sustainable Urban Development, Traffic Engineering and Management, Transport Planning, Highway Design and Construction and Economic and Environmental Evaluation of Transport Projects

PEO4 To inculcate students in professional and effective communication skills, teamwork skills, excellence in research aptitude and ethical, societal responsibility in students and to succeed in Transportation Engineering profession through rigorous and global post graduate education.

PROGRAMME OUTCOMES (POs):

On successful completion of the two-year programme, the graduates will exhibit ability to

PO	Programme Outcomes
PO1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO4	Demonstrate in-depth knowledge in the applications of Transportation and Highway Projects dealing with Planning, Design, Evaluation and Modeling.
PO5	Critically analyze complex transportation problems in developing a sustainable transportation and applying the basic tools of Mathematical modeling that gives a firm grasp of the mathematical theory necessary to understand and build such models.
PO6	Students will be able to design and develop appropriate analytical solutions and strategies for new innovative technologies that incorporate information and Communication Technologies into the transport sector that helps to resolve the problems integrating Transport and Landuse development.

PEO/PO Mapping:

PEO	PO					
	1	2	3	4	5	6
I.	3	2	3	3	3	2
II.	3	3	2	3	3	3
III.	3	3	2	3	3	2
IV.	3	3	2	3	2	3

• 1-low, 2-medium, 3-high

MAPPING OF COURSE OUTCOME AND PROGRAMME OUTCOME:

		COURSE NAME	PO1	PO2	PO3	PO4	PO5	PO6
YEAR I	SEMESTER I	Statistical Methods for Transportation Engineers	3	3	3	3	2	2
		Research Methodology and IPR						
		Traffic Engineering Design and Management	3	2	3	3	2	3
		Design and Construction of Flexible Pavements	2	2	3	3	3	3
		Urban and Regional Planning	3	3	3	2	3	3
		Professional Elective I						
	SEMESTER II	Transportation Systems Planning	3	2	3	3	3	3
		Transportation Economics	2	3	3	3	3	3
		Design and Construction of Rigid Pavements	3	3	3	3	3	2
		Traffic Flow Theory	2	3	3	3	3	3
		Professional Elective II						
		Computer Aided Design Laboratory	2	3	3	3	2	3
		Pavement Evaluation Laboratory	3	3	3	2	3	3
		Seminar	2	3	2	2	1	1
YEAR II	SEMESTER III	Professional Elective III						
		Professional Elective IV						
		Professional Elective V						
		Practical Training (4 Weeks)	2	2	2	2	2	2
		Project Work I	2	2	3	3	3	3
	SEMESTER IV	Project Work II	2	2	3	3	3	3

• 1-low, 2-medium, 3-high

MAPPING FOR PROFESSIONAL ELECTIVE COURSES [PEC]

S. NO.	COURSE TITLE	PO1	PO2	PO3	PO4	PO5	PO6
1.	Mass Transit System Planning	3	2	3	3	3	3
2.	Waterways Transportation System – Planning And Design	3	2	3	3	3	3
3.	Airport System Planning And Design	2	2	2	3	3	3
4.	Geospatial Techniques	2	2	3	3	3	3
5.	Analytical Techniques in Transportation Engineering	2	2	2	2	2	2
6.	Dynamic Simulation Modeling for Sustainable Transportation and Management	3	3	3	3	3	3
7.	Computational Techniques in Transportation Engineering	2	2	2	2	2	2
8.	Sustainable Urban and Transport Planning	3	2	3	3	3	3
9.	Intelligent Transportation Systems	2	2	3	3	3	3
10.	Pavement Rehabilitation and Management System	3	2	3	2	3	3
11.	Environmental Impact Assessment of Transportation Projects	2	2	3	3	2	2
12.	Urban Infrastructure and Asset Management	2	2	2	2	2	2
13.	Logistics in Transportation Engineering	2	3	3	3	3	2
14.	Road Safety System	3	3	3	3	3	3
15.	Geosynthetics for Pavements	3	2	3	2	3	3
16.	Pavement Geotechnics and Material Characterization	3	3	3	3	3	2
17.	Optimization Methods in Transportation	2	1	1	2	2	2

ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
M.E. TRANSPORTATION ENGINEERING (FULL-TIME)
REGULATIONS – 2023
CHOICE BASED CREDIT SYSTEM
CURRICULA AND SYLLABI FOR I TO IV SEMESTERS

SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	TE3101	Statistical Methods for Transportation Engineers	FC	4	0	0	4	4
2.	TE3102	Traffic Engineering Design and Management	PCC	3	0	4	7	5
3.	TE3103	Design and Construction of Flexible Pavements	PCC	3	0	4	7	5
4.	TE3104	Urban and Regional Planning	PCC	3	0	0	3	3
5.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
6.		Professional Elective I	PEC	3	0	0	3	3
			TOTAL	**18**	**1**	**8**	**27**	**23**

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	TE3201	Transportation Systems Planning	PCC	3	0	0	3	3
2.	TE3202	Transportation Economics	PCC	3	0	0	3	3
3.	TE3203	Design of Construction of Rigid Pavements	PCC	3	0	0	3	3
4.	TE3204	Traffic Flow Theory	PCC	3	0	0	3	3
5.		Professional Elective II	PEC	3	0	0	3	3
PRACTICALS								
6.	TE3211	Computer-Aided Design Laboratory	PCC	0	0	4	4	2
7.	TE3212	Pavement Evaluation Laboratory	PCC	0	0	4	4	2
8.	TE3213	Seminar	EEC	0	0	2	2	1
			TOTAL	**18**	**0**	**10**	**28**	**20**

SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Professional Elective III	PEC	3	0	0	3	3
2.		Professional Elective IV	PEC	3	0	0	3	3
3.		Professional Elective V	PEC	3	0	0	3	3
PRACTICALS								
4.	TE3311	Practical Training (4 Weeks)	EEC	0	0	0	0	2
5.	TE3312	Project Work I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**12**	**17**

SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	TE3411	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS TO BE EARNED FOR AWARD OF THE DEGREE: 72 CREDITS

FOUNDATION COURSES (FC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			Lecture	Tutorial	Practical	
1.	TE3101	Statistical Methods for Transportation Engineers	4	0	0	4

PROFESSIONAL CORE COURSES (PCC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			Lecture	Tutorial	Practical	
1.	TE3102	Traffic Engineering Design and Management	3	0	4	5
2.	TE3103	Design and Construction of flexible pavements	3	0	4	5
3.	TE3104	Urban and Regional Planning	3	0	0	3
4.	TE3201	Transportation Systems Planning	3	0	0	3
5.	TE3202	Transportation Economics	3	0	0	3
6.	TE3203	Design and Construction of Rigid Pavements	3	0	0	3
7.	TE3204	Traffic Flow Theory	3	0	0	3

8.	TE3211	Computer-Aided Design Laboratory	0	0	4	2
9.	TE3212	Pavement Evaluation Laboratory	0	0	4	2

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			Lecture	Tutorial	Practical	
1.	RM3151	Research Methodology and IPR	2	1	0	3
					TOTAL CREDITS	**3**

PROFESSIONAL ELECTIVE COURSES (PEC)

SL NO.	COURSE CODE.	COURSE TITLE	PERIODS PER			CREDITS
			L	T	P	
1.	TE3001	Mass Transit System Planning	3	0	0	3
2.	TE3002	Waterways Transportation System – Planning And Design	3	0	0	3
3.	TE3003	Airport System Planning And Design	3	0	0	3
4.	AG3020	Geospatial Techniques	3	0	0	3
5.	TE3004	Analytical Techniques in Transportation Engineering	3	0	0	3
6.	TE3005	Dynamic Simulation Modeling for Sustainable Transportation and Management	3	0	0	3
7.	TE3006	Computational Techniques in Transportation Engineering	3	0	0	3
8.	TE3007	Sustainable Urban and Transport Planning	3	0	0	3
9.	TE3008	Intelligent Transportation Systems	3	0	0	3
10.	TE3009	Pavement Rehabilitation and Management System	3	0	0	3
11.	TE3010	Environmental Impact Assessment of Transportation Projects	3	0	0	3
12.	TE3011	Urban Infrastructure and Asset Management	3	0	0	3
13.	TE3012	Logistics in Transportation Engineering	3	0	0	3
14.	TE3013	Road Safety System	3	0	0	3
15.	TE3014	Geosynthetics for Pavements	3	0	0	3
16.	TE3015	Pavement Geotechnics and Material Characterization	3	0	0	3
17.	TE3016	Optimization Methods in Transportation	3	0	0	3

SUMMARY

	NAME OF THE PROGRAMME: M.E.TRANSPORTATION ENGINEERING					
	SUBJECT AREA	**CREDITS PER SEMESTER**				**CREDITS TOTAL**
		I	**II**	**III**	**IV**	
1.	FC	4	-	-	-	4
2.	PCC	13	16	-	-	29
3.	PEC	3	3	9	-	15
4.	RMC	3	-	-	-	3
5.	EEC	-	1	8	12	21
6.	**TOTAL CREDITS**	**23**	**20**	**17**	**12**	**72**

TE3101 STATISTICAL METHODS FOR TRANSPORTATION ENGINEERS L T P C
4 0 0 4

UNIT I PROBABILITY DISTRIBUTIONS 12

Introduction to probability and random variables, Normal distribution, Binomial distribution, Poisson distribution, Geometric distribution, Hyper Geometric distribution, Log- Normal distribution, Uniform distribution, Exponential distribution, Gamma distribution, Beta distribution, and Weibull distribution, applications in transportation engineering, vehicle volume count, speed & delay studies and Vehicle arrival studies.

UNIT II STATISTICAL INFERENCE AND TESTS OF SIGNIFICANCE: 12

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.

UNIT III CORRELATION AND REGRESSION 12

Multiple and Partial Correlation - Method of Least Squares- Plane of Regression - Properties of Residuals - Coefficient of Multiple Correlation - Coefficient of Partial Correlation - Multiple Correlation with total and partial correlations - Regression and Partial correlations in terms of lower order coefficients, applications in transportation engineering, example in trip generation model- case studies

UNIT IV ESTIMATION THEORY 12

Estimators: Unbiasedness, Consistency, Efficiency and Sufficiency–Maximum Likelihood Estimation – Method of moments, Discrete choice model, applications in transportation engineering, example in accident prediction model, Mode choice model - case studies

UNIT V MULTIVARIATE ANALYSIS 12

Random vectors and Matrices – Mean vectors and Covariance matrices – Multivariate Normal density and its properties – Principal components: Population principal components – Principal components from standardized variables, applications in transportation engineering- case studies

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1: Apply probability distributions to analyze transportation data.

CO2: Use various test statistics in hypothesis testing for mean and variances of large and small samples.

CO3: Determine the regression line using the method of least square and also to calculate the partial and multiple correlation coefficient for the given set of data points.

CO4: Obtain the value of the point estimators using the method of moments and method of maximum likelihood.

CO5: Get exposure to the principal component analysis of random vectors and matrices.

REFERENCES:

1. Statistical and Econometric Methods for Transportation Data Analysis, Washington, S.P., Karlaftis, M.G., Mannering, F., Anastasopoulos, P., CRC Press, 2020, Third Edition.
2. Statistical Techniques for Transportation Engineering, Molugaram, K., Rao, G.S., Shah, A., Davergave, N., Butterworth-Heinemann, 2017, First Edition.
3. Devore, J.L., "Probability and Statistics for Engineering and the Sciences", Thomson and Duxbury, Singapore, 6th Edition, Boston, 2004.
4. Gupta, S.C., and Kapoor, V.K., "Fundamentals of Mathematical Statistics", Sultan Chand and Sons, Eleventh Edition, Reprint, New Delhi, 2019.
5. Johnson, R. A. and Gupta, C. B., "Miller & Freund's Probability and Statistics for Engineers", Pearson Education, Asia, Eighth Edition, New Delhi, 2015.
6. Johnson, R.A., and Wichern, D.W., "Applied Multivariate Statistical Analysis", Pearson Education, Sixth Edition, New Delhi, 2013.
7. Spiegel, M.R. and Stephens, L.J.," Schaum's outlines on Statistics", Tata McGraw-Hill, 6th Edition, New York, 2018.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg	**3**	**3**	**3**	**3**	**2**	**2**

• 1-low, 2-medium, 3-higH

TE3102 TRAFFIC ENGINEERING DESIGN AND MANAGEMENT L T P C
3 0 4 5

UNIT I TRAFFIC CHARACTERISTICS 9

Elements of traffic engineering-Characteristics Road user, vehicle, road-Geometric Design-Overview- Traffic Stream Characteristics-Volume and Capacity-LOS for uninterrupted traffic flow - Headway concepts and applications

UNIT II SURVEYS AND STUDIES IN TRAFFIC ENGINEERING 9

Conventional and Modern Methods of Traffic Survey and Studies –types of Data-Volume Studies-Speed Studies-Travel time and delay studies-Intersection Studies-Pedestrian Studies-Parking studies- Accident studies -Vehicle detection methods - Origin and Destination – Fundamental derived parameter, introduction.

UNIT III INTERSECTION DESIGN AND ANALYSIS 9

At grade intersection – Uncontrolled, Channelization, Rotary, mini roundabouts, Warrants for signalization, design control variables, lost time estimation, saturation flow rate and capacity, dilemma zone analysis, signal timing design methods, pedestrian considerations, queue length and control delay, signal coordination for urban streets, adaptive traffic signals, ATC – Grade Separated Interchanges-Traffic signs, Road marking, Traffic Control Aids, Street furniture, Road Arboriculture.

UNIT IV TRAFFIC OPERATION AND MANAGEMENT 9

Traffic Regulation, Cost Effective Management Measures – Traffic System Management and Travel Demand Management - Congestion Management, Traffic Calming and Pricing-Design of Cycle Tracks, Pedestrian Facilities, Parking Facilities – On Street and Off-Street Multi-level car Parking – Street Lighting-

UNIT V INTELLIGENT TRANSPORT SYSTEM 9

Introduction to Intelligent Transportation Systems (ITS)- Sensors - Travel information– ITS Applications- Electronic Toll Collection- Passenger Information System- Vehicle Tracking- -Traffic Enforcement.

Laboratory Session:

1. TRAFFIC STUDIES

a. Volume Studies
   i. Classification of Traffic Volume at Mid-Block Section and Intersections, Manual, and Mechanical Methods- V/C, LOS
b. Speed Studies: Spot Speed Studies - Radar Speed Meters, Travel Time, and delay studies by manual and GPS methods.

c. Parking Surveys: Parking Inventory and Turnover Studies.
d. Physical inventory using total station survey equipment.
e. Environmental impact – Noise studies and vehicular emission Measurement-Lighting studies

2. TRANSPORTATION PLANNING STUDIES

a. Origin and destination studies
The household survey, - OD Matrix-.
Roadside Interview

3. Statistical Analysis using MATLAB/ SPSS **60**

TOTAL: 105 PERIODS

COURSE OUTCOME:

CO1 Interpret the fundamentals of traffic characteristics
CO2 Construct the various applications of traffic surveys and studies
CO3 Design & analysis of different types of intersections & interchanges
CO4 Perceive diverse Traffic system management techniques and operations
CO5 Interpret the application of IT and sensors in traveller & passenger information, ETC, vehicle racking in the field of Intelligent transportation system
CO6 Conduct field studies for transportation planning studies.

REFERENCES:

1. Roger.P.Roess,Elena S..Prassas and William R. McShane," Traffic Engineer", 5th edition, Pearson Education India,2019.
2. R Srinivasa KumarI, ntroduction to Traffic Engineering, The Orient Blackswan; South Asian edition, 2018
3. James L. Pline (Edr), Traffic Engineering Hand Book, Institute of Transportation Engineers.
4. Nicholas T.Garber, Lester A Hoel, Traffic and Highway Engineering, Revised Second Edition, ITP, California, USA,2008
5. Wolfgang S.Homburger et.al. Fundamentals of Traffic Engineering 15th Edition, Institute of Transportation Studies, University of California, Berkely,2001
6. Thomas Curinan, An Introduction Traffic Engineering–A Manual for Data Collection and Analysis, Books Cole, UK,2001
7. Washington DC , USA,1999 Pignataro, L.J., Traffic Engineering–Theory & Practice, John Wiley, 1985.
8. AASHTOA Policy on Geometric Design of Highway and Streets

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	3	3
CO4	3	2	3	3	3	3
CO5	3	2	2	2	2	3
CO6	3	2	2	2	2	3
Avg	**3**	**2**	**3**	**3**	**2**	**3**

• 1-low, 2-medium, 3-higH

TE3103 DESIGN AND CONSTRUCTION OF FLEXIBLE PAVEMENT L T P C
3 0 4 5

UNIT I INTRODUCTION TO PAVEMENT ENGINEERING 9

Introduction to highway and airport pavement-Types, components and function of pavement layers - Properties of Subgrade soil characterization- Soil Classification– Laboratory and In situ soil testing- Index properties of soils, determination of strength properties of soil for flexible and rigid pavements, suitability of different types of soil for construction of embankment and other pavement layers, Laboratory and field compaction of soil, Soil stabilization- different methods.

UNIT II MATERIALS FOR FLEXIBLE PAVEMENT 10

Types of aggregates; Sampling of aggregates; testing the properties of aggregates; Bitumen sources and manufacturing, Types of Bitumen - Bitumen emulsion- Cutback bitumen- modified binders - Properties, and testing of Binders - Rheological properties of bitumen, Ageing, PAV, RTFOT, SEM, TGA, FTIR. Use of Alternate Materials in Pavement- .

UNIT III DESIGN OF FLEXIBLE PAVEMENT 9

Stresses and deflections in homogeneous masses – Burmister's two layer, three layer and multi-layer theories – wheel load stresses – ESWL of multiple wheels – repeated loads and EWL factors - Empirical, Semi-empirical, Analytical and Mechanistic-empirical approaches -sustained loads and pavement behaviour under traffic loads. Principle, design steps, advantages and applications of different pavement design methods – Group Index, CBR, McLeod, Kansas triaxial test, IRC. and Asphalt Institute methods.

UNIT IV DESIGN OF BITUMINOUS MIXES AND TESTING 10

Mix Design for bituminous pavement- Marshall Mix Design- and Asphalt Institute methods – Superpave mix design - Warm Mix and Cold Mix. Performance evaluation of bituminous mixes – ITS, Dynamic creep test Fatigue Beam Test, Cantabro, Drain Down - Pavement Recycling-RAP.

UNIT V FLEXIBLE PAVEMENT CONSTRUCTION AND QUALITY CONTROL 7

Pavement construction equipments- Excavators, graders, vibratory rollers, sensor pavers, computerized asphalt mix plant, plants and trucks for ready mix concrete, slip form paver – working principle, advantages and limitations. Earthwork and construction– roadway excavation, embankment construction- Subbase – Construction of gravel and stabilized bases; Base – WBM base, wet mix macadam; Bituminous pavements – preparation & laying of tack coat, bituminous macadam, mixed seal surfacing, bituminous concrete;–Drainage – Estimation of flow, surface drainage, sub-surface drainage systems--different types of drains. Quality control tests-Destructive and Non Destructive testing. Pavement Evaluation.

Laboratory session :

Pavement Material Testing and Bituminous Mix -Design and Testing **60**

TOTAL: 105 PERIODS

COURSE OUTCOME

CO1 Knowledge on the Soil characteristics, testing and stabilization Techniques
CO2 Understand the different types of materials used for construction of flexible pavement.
CO3 Understand the concepts and stress distribution in flexible pavements
CO4 Understand the different types of bituminous mixes and testing methods
CO5 Understand the construction methods and quality control of flexible pavements
CO6 Carry out hands on experience in designing Bituminous mixes and testing.

REFERENCES:

1. Khanna, S.K. and Justo C.E.G.and Veeraragavan, A, "Highway Engineering", New Chand and Brothers, Revised 10th Edition, 2014
2. Yoder and Witczak, Priniciples of Pavement Design, John Wiley and Sons.
3. Prithvi Singh Kandhal, Bituminous Road Construction in India, Prentice Hall of India Publications,2018

4. Alkins and Harold, "Highway Material", Prentice Hall, Pearson,2003.
5. Kerbs and Walkes, "Highway Materials", McGraw Hill BookCo.2007.
6. Specifications for" Road and Bridge works", Fourth Revision, MoSRT & H (India), 2001.
7. Peurify.R.L., "Construction Planning, Equipment and Methods", McGraw Hill Publishers, New York, 2000.
8. S.C.Sharma., "Construction Equipment and its Management", Khanna Publishers, New Delhi, 1988.
9. Yang H. Huang, "Pavement Analysis and Design", Prentice Hall, NewJersy,1993
10. Ralph Haos, "Ronald Hudson and Zaniesuki, Modern Pavement Management", Kneigr Publications, 1994
11. Read, J. And Whiteoak, D., "The Shell Bitumen Handbook", Fifth edition, Shell Bitumen, Thomas Telford Publishing, London, 2003.
12. Relevant IRC and IS codes and ASTM Standards

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	2	2
CO2	2	2	2	2	2	3
CO3	2	2	3	3	3	3
CO4	2	2	3	3	3	3
CO5	2	2	3	3	3	3
CO6	2	2	3	3	3	3
Avg	**2**	**2**	**3**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high,

TE3104 URBAN AND REGIONAL PLANNING L T P C
3 0 0 3

UNIT I BASIC CONCEPTS POLICIES AND PROGRAMMES 8

Definitions and Concept- Urbanization, Towns, Cities, Metropolis, Megalopolis, Satellite and New towns, CBD, Peri-urban areas, Suburban areas, Census Definition, Classification of urban settlements, TOD, National policies, National Urban Transport Policy 2006, National Policy for Urban street vendors 2009- Programme objectives and salient features of Jawaharlal Nehru National Urban Renewal Mission (JNNURM), Smart cities mission- Smart cities mission- Urban infrastructure development scheme for small and medium towns (UIDSSMT), Housing for all

UNIT II PLANNING PROCESS 8

Steps in Planning Process- Plans; levels; objectives, content, and data requirement-regional plan, master plan, detail development plan, city development plan, development control regulation, Zoning Regulation, Layout, and Building Regulations- Urban renewal and resilient cities, Special Economic Zones(SEZ).

UNIT III SOCIO-ECONOMIC AND SPATIAL PLANNING 10

Economic and social concepts in urban and regional planning and their relevance, Economic principles of zoning, Components of sustainable development, Planning for Inclusive Development, Compact cities, Quality of life-Form of cities, issues related to inner city fringe areas, and suburban areas, Application of Remote sensing and GIS in Urban and Regional Planning, Land Use Planning.

UNIT IV PROJECT FORMULATION AND EVALUATION 10

Constraints for plan implementation – Industrial, Financial, and Legal Constraints, Institutional Arrangements for Urban Development – Financing of Urban Developments - Legislation related to Urban Development. Urban infrastructure projects planning, appraisal, formulation, feasibility, and preparation of detailed project reports, site planning, layout, road network, and utilities.

UNIT V URBAN GOVERNANCE AND MANAGEMENT 9

Planning laws; Town and Country planning act: Urban Development Authorities Act, Constitutional (74th Amendment) Act 1992- Local bodies, Functions, powers and Interfaces-development of small town and Low Emission Zones -case studies

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 Basic definitions and knowledge on various Government Policies.
CO2 Understand different types of Plans and Planning process.
CO3 Knowledge on various development strategies.
CO4 Students will be in a position to formulate, appraise and conduct feasibility studies on urban projects.
CO5 Knowledge on various Government Acts.

REFERENCES:

1. CMDA, Second Master Plan for Chennai, Chennai 2008
2. CMDA 2018, “Combined Development Regulation of Building Rules 2018”, CMDA, Chennai.
3. Charles Montgomery, 2013, Happy City – Transforming our lives through Urban Design, British Columbia Arts Council Press, USA.
4. Goel, S.L Urban Development and Management, Deep and Deep publications, New Delhi 2002
5. George Chadwick, "A Systems view of planning", Pergamon press, Oxford 1978
6. Singh V.B, "Revitalised Urban Administration" in India, Kalpaz publication, Delhi 2001
7. Edwin S.Mills and Charles M.Becker, "Studies In Urban Development", A World Bank Publication, 1986
8. Thooyavan. K.R, "Human Settlements – A Planning Guide to Beginners. M.A Publications, Chennai 2005.
9. Tumlin Jeffrey, "Sustainable Transportation Planning Tools for Creating Vibrant Healthy and Resilient Communities", John Wiley And Sons, 2012.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	3	2
CO2	2	2	3	2	2	3
CO3	2	3	3	2	3	2
CO4	3	3	3	3	3	3
CO5	3	3	2	2	3	3
Avg	**3**	**3**	**3**	**2**	**3**	**3**

• 1-low, 2-medium, 3-high,

RM3151 RESEARCH METHODOLOGY AND IPR L T P C
2 1 0 3

UNIT I RESEARCH PROBLEM FORMULATION 9

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction,

methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, the student can

CO1: Describe different types of research; identify, review and define the research problem

CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data

CO3: Explain the process of data analysis; interpret and present the result in suitable form

CO4: Explain about Intellectual property rights, types and procedures

CO5: Execute patent filing and licensing

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
3. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.
5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

TE3201 TRANSPORTATION SYSTEMS PLANNING L T P C
3 0 0 3

UNIT I TRANSPORTATION SYSTEM STATUS 10

Status of existing Transportation System – Significance in Urban & Rural planning- Systems Approach to Transport Planning – Stages in Transportation Planning – Transport Systems and Planning Considerations -Concepts of Zoning – Inventory of Transport and other activities –Surveys -Planning Policies at National and other levels.

UNIT II TRIP END & TRIP INTERCHANGE MODELS 9

Travel Behavior- Travel Demand Estimation and Modeling-- Trip Generation Models - Category analysis –Different Types of Trip End and trip Interchange models- Sequential Modeling Process.

UNIT III MODE CHOICE MODELS 8

Modal Split and Types of Mode Choice Models – Probabilistic models – Utility Functions – Logit Probit and Nested Models.

UNIT IV TRIP ASSIGNMENT MODELS 8

Traffic Assignment model types – Dynamic Traffic Assignment - Multimodal Transportation Planning -Advancement in four stage modeling - Non-Transportation and Sustainable Solutions to Transportation Problems.

UNIT V LAND USE TRANSPORT (LUT) MODELS 10

Urban Forms - Land Use Effect on Travel Demand – Types of Land Use Modeling – Lowery & Garin model and Applications –LUT Conception with Simulation Modeling - Case Studies.

TOTAL: 45 PERIODS

COURSE OUTCOME:

CO1 Knowledge on basics of Urban Transport Planning with Status of Existing Situations
CO2 Understand the first two stages of conventional transportation modelling
CO3 Modelling methodologies of third stages of conventional transportation planning
CO4 Study on methodologies of the last stage of conventional transportation modelling
CO5 Know the rudiments of land use transport (LUT) modelling & models of developed world & to conduct research pertinent to LUT modelling and to communicate effectively to different stakeholders as well as engage in independent life-long learning

REFERENCES:

1. Juan de Dios Ortúzar, Luis G. Willumsen (2011), “Modelling Transport”, 4th Edition, Wiley
2. Sarkar, Pradip Kumar, Maitri, Vinay, Joshi, G.J (2017) “Transportation Planning : Principles, Practices And Policies” 2nd Edition, PHI Learning Private Limited, Delhi
3. Milan janic (2016), “Transport Systems: Modelling, Planning, and Evaluation”-1st Edition**,** CRC Press Publication, USA.
4. John Black (2018), “Urban Transport Planning: Theory and Practice”- 1st Edition, Routledge Publication, USA.
5. Agostino Nuzzolo& William H. K. Lam (2016), “Modelling Intelligent Multi-Modal Transit Systems”- 1st Edition, CRC Press Publication, USA.
6. Reid Ewing, Keith Bartholomew (2018), “Best Practices in Metropolitan Transportation Planning ”- 1st Edition,Routledge Publication, USA
7. Papacostas C.S., Prevedouros (2015), "Transportation Engineering and Planning, 3rd Edition, Pearson Education India, New Delhi, India.
8. John D.Edwards (Edr.) (1999), "Transportation Planning Hand Book", 2nd Edition, Institute of Transportation Engineers, Prentice Hall Inc., Washington DC, USA.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2	3	2
CO2	2	3	3	3	3	2
CO3	2	3	3	3	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3
Avg	3	2	3	3	3	3

• 1-low, 2-medium, 3-high,

TE3202 TRANSPORTATION ECONOMICS L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Overview of Feasibility Studies and Detailed Project Report (DPR) preparation, CMP, CTTS with case studies - Densification of corridors, BRTS projects- Traffic studies- Bid review

UNIT II PROJECT PLANNING & APPRAISAL 9

Planning –Network Scheduling, project monitoring, Critical Path Method, Program Evaluation & Review Technique, Planning and Scheduling of Activity Networks, Assumptions in PERT Modelling,

UNIT III PROJECT FORMULATION-TECHNICAL &SOCIAL EVALUATION 9

Road user cost, Vehicle operating costs: Fuel costs - Maintenance and spares, Depreciation - Crew costs - Value of travel time savings - Accident costs. Social Rehabilitation-Environmental impact.

UNIT IV ECONOMIC EVALUATION OF TRANSPORTATION PROJECTS 9

Economic analysis of projects – Methods, costs, and benefits of transport projects, basic principles of economic evaluation, elements of engineering economics, methods of economic evaluation, benefit-cost ratio method, first-year rate of return, net present value method, internal rate of return method, comparison of the various methods of economic evaluation, life cycle cost analysis, case studies,

UNIT V FINANCING 9

Financing of road projects- Sources of revenue -Private Public Partnership (PPP), BOT, BOOT, Special Purpose Vehicles, Financial Risk Analysis – Value for Money analysis, Toll collection - Case Studies.

TOTAL: 45 PERIODS

COURSE OUTCOME:

CO1 Understand procedure to prepare DPR, CMP, CTTS
CO2 Understand the concept of project planning and Proposal
CO3 Evaluate road user costs using modern tools and techniques.
CO4 Understand economic evaluation methods and their application in urban transport projects.
CO5 Understand the principles of financing transport systems and conduct risk analysis.

REFERENCES

1. Transport Policy and Funding, Dai Nakagawa and RyojiMatsunaka, Elsevier, Oxford, UK,2006.
2. Urban Transportation Economics, Kenneth A. Small and Erik T. Verhoef, Routledge,London, 2006, Second Edition.
3. Highway Investment in Developing Countries, Institute of Civil Engineers, Thomas TelfordLtd., 1983.
4. Transport Investment and Economic Development, David Banister and Joseph Berechman, UCL Press, London, 2000.
5. Winfrey R, Highway Economic Analysis, International Textbook Company 1969.
6. Kenneth J. Button, Transport Economics, Elgar, 2010.
7. David A. Hensher, Ann M. Brewer, Transport: An Economics and Management Perspective, Oxford University Press, 2001.
8. Emile Quinet, Roger Vickerman, Principles of Transport Economics, Edward Elgar Pub, 2005
9. Road User Cost Study, Central Road Research Institute

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2	3	2
CO2	2	3	3	3	3	2
CO3	2	3	3	3	3	3
CO4	2	2	3	3	3	3
CO5	2	3	3	3	3	3
Avg	2	3	3	3	3	3

• 1-low, 2-medium, 3-high,

TE3203 DESIGN AND CONSTRUCTION OF RIGID PAVEMENTS L T P C
3 0 0 3

UNIT I MATERIALS FOR RIGID PAVEMENT DESIGN 9

Types of Concrete pavement- White topping pavement- Types and properties of Cement, Selection of aggregates, selection of cement and admixtures. Hydration of cement-testing for purity of cement-water, fibers.

UNIT II DESIGN OF CONCRETE PAVEMENT 9

Factors influencing design of rigid pavement- Stresses in concrete pavement- frictional, warping and wheel load stresses- axle load and axle load configuration. Thickness design – IITRIGID PAVE.-concrete overlays- dry lean concrete-Design of concrete pavement for low volume traffic- cross section of rigid pavements -IRC standards.

UNIT III MIX DESIGN PROPORTIONING OF RIGID PAVEMENT 9

Selection of grade of concrete- mix design of concrete pavement- proportioning of admixtures, fibers. compression and flexural testing of concrete.

UNIT IV CONSTRUCTION OF RIGID PAVEMENTS 9

Subgrade soil properties and preparation -stabilization-compaction. Granular sub base layer-provision of drainage and separation layer. Construction of Dry Lean Concrete- compaction-rolling -curing. Provision and cutting of joints, dowel bars and tie bars and reinforcement- surface texturing and tinning- resistance-Pavement Quality Concrete (PQC)- construction methods. Slip form and fixed form paving.

UNIT V QUALITY CONTROL AND MAINTENANCE OF RIGID PAVEMENT 9

Thickness of concrete pavement by core cutting and compression testing of cores- dry density. Hot weather concreting- cold weather concreting- Rain concreting - PQC quality control.

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1 Apply the knowledge of science and engineering fundamentals in developing an efficient pavement design concept.
CO2 Explain concepts and analysis of various stresses in rigid pavements.
CO3 Understanding and learning of proportioning and mix design of rigid pavements
CO4 Design and construction of rigid pavements
CO5 Understand the techniques for quality control and maintenance of rigid pavements

REFERENCES:

1. Yoder,E.J and Witezak, Principles of Pavement Design, John Wiley and Sons, 1975
2. Yang H. Huang, Pavement Analysis and Design, Prentice Hall, New Jersy,1993
3. IRC 37-2001, Guidelines for the Design of flexible Pavements, Indian Roads Congress
4. IRC 58-2002, Guidelines for the Design of Plain Jointed Rigid Pavements for Highways, Indian Roads Congress

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	2	3	3	2
CO2	2	3	3	3	3	2
CO3	3	3	3	2	3	2
CO4	3	3	3	3	3	3
CO5	3	3	3	3	2	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**

• 1-low, 2-medium, 3-high,

TE3204 TRAFFIC FLOW THEORY L T P C
3 0 0 3

UNIT I TRAFFIC FLOW FUNDAMENTALS 10

Traffic flow characteristics-macroscopic variables-microscopic variables, Measurement Techniques, Time-Space Diagram, Statistical distribution of traffic characteristics, Driver behavior- Gap acceptance, Vehicle arrival studies.

UNIT II TRAFFIC FLOW CHARACTERISTICS 10

Traffic Stream Model – Macroscopic Models, Microscopic Models: Car-Following Models, Lane Changing Model, Driver Behaviour Models, Pedestrian Behaviour Models, Shock Wave Theory

UNIT III QUEUING MODELS 8

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

UNIT IV TRAFFIC DELAYS 8

Delay at Intersections - Type of delays - Manual measurement – Saturated and oversaturated intersections – steady state delay model, Time dependent delay model- case studies.

UNIT V SIMULATION MODELS 9

Fundamentals and concepts, components of traffic simulation- Simulation Model and Classification, mathematical simulation model development, macroscopic, microscopic, and mesoscopic simulation models, software for simulation, calibration and validation simulation model- statistical analysis of simulation data.

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1 Understand the basics of traffic flow, including parameters, characteristics, and probabilistic aspects.
CO2 Explore different types of traffic flow, macroscopic and microscopic models, and driver and pedestrian behavior.
CO3 Learn about queuing theory, including queue patterns, analysis, and examples.
CO4 Knowledge about the types of delays at intersections, measurement methods, and arrival patterns.
CO5 overview of traffic simulation, including its components, types of models, and software used for development, calibration, and validation.

REFERENCE:

1. Lily Elefteriadou. An Introduction to Traffic Flow Theory, Springer New York, NY, 2014
2. Daiheng Ni, Traffic Flow Theory- Characteristics, Experimental Methods, and Numerical Techniques, Butterworth-Heinemann Inc, 2016
3. Drew, D.R., Traffic Flow Theory and Control, McGraw Hill., 1978.
4. TRB, Traffic Flow Theory - A Monograph, SR, 165, 1975.
5. Burrough P.A. and Rachel A. McDonell, Principles of Geographical Information Systems, Oxford Publication, 2004.
6. Sussman, J. M., Perspective on ITS, Artech House Publishers, 2005.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	3
CO2	2	3	3	2	3	3
CO3	3	3	3	3	3	3
CO4	2	3	2	3	3	3
CO5	2	2	3	2	3	3
Avg	**2**	**3**	**3**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high,

TE3211 COMPUTER-AIDED DESIGN LABORATORY L T P C
0 0 4 2

EXCERCISES

1. Traffic Projects

a. Traffic signal design using TRANSYT
b. Road alignment design using MXRoad.
c. Small Area Transport Planning using CUBE - Travel demand modeling with Trip Generation, Trip Distribution, Trip Assignment and Trip Assignment.
d. Junction Design or Small Area Traffic Management using VISSIM

TOTAL : 60 PERIODS

COURSE OUTCOME:

CO1 Apply various Transportation software tools and their application in solving transportation problems on a real time basis

CO2 Understand and apply software programs for arriving solutions to various practical design problems in Transportation Engineering

CO3 Apply Transportation simulation software tools and their application in solving transportation problems on a real time basis

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	3	2	3
CO2	3	3	3	2	2	3
CO3	3	3	2	3	3	3
Avg	**2**	**3**	**3**	**3**	**2**	**3**

• 1-low, 2-medium, 3-high,

TE3212 PAVEMENT EVALUATION LABORATORY L T P C
0 0 4 2

EXCERCISES

a. Design of Flexible Pavement
b. Design of Rigid Pavement
c. Visual pavement condition survey -, potholes, raveling, edge breaking ,cracking, etc.
d. Skid resistance measurements.
e. Texture Depth.
f. MERLIN
g. Quality Control Assessment of Roads.

TOTAL : 60 PERIODS

COURSE OUTCOME

CO1 Apply various Transportation software tools and their application in solving transportation problems on a real time basis

CO2 Understand and apply software programs for arriving solutions to various practical design problems in Transportation Engineering

CO3 Apply and analyse various plans and design various highway projects and evaluate their economical analysis

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2	3	3
CO2	3	3	3	2	3	3
CO3	2	3	3	3	3	2
Avg	**3**	**3**	**3**	**2**	**3**	**3**

• 1-low, 2-medium, 3-high,

TE3213 **SEMINAR** **L T P C**
0 0 2 1

SYLLABUS CONTENT

The students will work for two hours per week guided by a group of faculty members. They will be asked to select any topic of their choice related to transportation engineering. Students are asked to submit a brief report on their seminar topic. Similarly, the students will have to present a seminar of not less than fifteen minutes and not more than thirty minutes on the technical topic. They will also answer the queries on the topic. The students as audience also should interact. Evaluation will be based on the technical presentation and the report and also on the interaction during the seminar.

TOTAL : 30 PERIODS

COURSE OUTCOME:

CO1 Identify various innovative and latest advancements in the transportation field through research studies.

CO2 Improve their communication skills and understand the art of writing research work through analysis of a specific topic in the related field.

CO3 Learn to make good presentation and explain a concept.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	1	1
CO2	2	3	2	2	1	1
CO3	2	3	2	2	1	1
Avg	**2**	**3**	**2**	**2**	**1**	**1**

• 1-low, 2-medium, 3-high,

TE3311 **PRACTICAL TRAINING (4 WEEKS)** **L T P C**
0 0 0 2

Syllabus Content:

- Students individually undertake training in reputed Companies identified by Division of Transportation Engineering dealing with traffic and transportation, highway projects, road construction and urban planning during the summer vacation for a specified period of four weeks.
- Students allowed to get field exposure and effectively interact with transport engineers
- At the end of training, a detailed report on the work done should be submitted to the course coordinator
- Students will be evaluated through a viva-voce examination by a team of internal staff.

COURSE OUTCOME:

CO1 Understand the various organizations and to have an exposure on projects carried out and understand the real field problem and compare the theoretical knowledge with field

CO2 Develop knowledge in analysing and uunderstand the professional ethics

CO3 Solve Transport related problems in the field either individually or in team

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	2	2
CO2	2	2	2	2	2	2
CO3	2	3	2	2	2	2
Avg	**2**	**2**	**2**	**2**	**2**	**2**

• 1-low, 2-medium, 3-high

TE3312 **PROJECT WORK I** **L T P C**

0 0 12 6

SYLLABUS:

The student individually works on a specific topic approved by faculty member who is familiar in this area of interest. The student can select any topic which is relevant to his/her specialization of the programme. The topic may be experimental or analytical or case studies. At the end of the semester, a detailed report on the work done should be submitted which contains clear definition of the identified problem, detailed literature review related to the area of work and methodology for carrying out the work. The students will be evaluated through a viva-voce examination by a panel of examiners including one external examiner.

TOTAL: 180 PERIODS

COURSE OUTCOME:

- students will be able to

CO1 Identify transportation engineering problems and critically evaluate literature in a chosen area of research and establish the scope of work

CO2 Develop study methodology, and identify appropriate techniques to analyze complex transportation engineering problems

CO3 Apply engineering and management principles through efficient handling of the project and demonstrate a sound technical knowledge of their selected project topic

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	2	2
CO2	2	2	3	3	3	3
CO3	2	2	3	3	3	3
Avg	**2**	**2**	**3**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high

TE3411 **PROJECT WORK II** **L T P C**
0 0 24 12

SYLLABUS:

The student should continue the Project Work I work on the selected topic as per the formulated methodology. At the end of the semester, after completing the work to the satisfaction of the supervisor and review committee, a detailed report should be prepared and submitted to the head of the department. The students will be evaluated based on the report and the viva-voce examination by a panel of examiners including one external examiner.

TOTAL: 360 PERIODS

COURSE OUTCOME:

- students will be able to

CO1 Identify transportation engineering problems and critically evaluate literature in a chosen area of research and establish the scope of work

CO2 Develop study methodology, and identify appropriate techniques to analyze complex transportation engineering problems

CO3 Apply engineering and management principles through efficient handling of the project and demonstrate a sound technical knowledge of their selected project topic

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	2	2
CO2	2	2	3	3	3	3
CO3	2	2	3	3	3	3
Avg	**2**	**2**	**3**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high

PROFESSIONAL ELECTIVE COURSES

TE3001 **MASS TRANSIT SYSTEM PLANNING** **L T P C**
3 0 0 3

UNIT I TRANSIT SYSTEM AND ISSUES 6

Introduction to Mass Transport – Role of various modes of Mass Transport – Problems and their Impact – Transport System Performance at National, State and International levels – Public Transport and Urban Development Strategies -National Transport Policy.

UNIT II PUBLIC TRANSIT SYSTEM 9

Urban Transport System – Public Transport System Re-genesis and Technology – Physical performance of Public Transport System – Characteristics of Rail Transit – Vehicle Characteristics. Ridership Estimation- Route Planning.

UNIT III BUS TRANSIT PLANNING AND SCHEDULING 10

Route Planning and Scheduling – Bus Transport System – Performance and Evaluation – Scheduling Conceptual patterns of bus service – Network Planning and Analysis – Bus Transport System Pricing – Bus Transit System Integration – Analytical Tools and Techniques for Operation and Management – Bus Rapid Transit Systems – Case Studies

UNIT IV RAIL TRANSIT TERMINALS AND PERFORMANCE EVALUATION 10

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

Planning and Design- Urban Rail Transit Planning – MRTS – LRTS, Metro Rail – Monorail – Network Design, Capacity and Traffic Fore casting - Case Studies

UNIT V IMPACT OF TRANSIT 10

Policies and Strategies for Mass Transport – Need for Integrated Approach – Unified Transport Authorities – Institutional arrangement – Urban Transport Fund – Parking Policies - Private Sector in Mass Transport – Multimodal Integration – Last mile connectivity – Transit Oriented Land Use Development – Case Studies

TOTAL: 45 PERIODS

COURSE OUTCOME:

CO1 Understand the basic concepts of mass transportation system, development strategies & policies

CO2 Inspect the public transport System performance, ridership & route planning

CO3 Compose bus transit network planning, scheduling, operation & management

CO4 Evaluate the performance of rail transit, construct terminal layout design & capacity forecasting

CO5 Appraise the Institutional arrangements, multimodal transit integration & impact of Transit Oriented Land Use

REFERENCES:

1. MichaelJ.Bruton,"An Introduction toTransportation Planning", Hutchinson,1985
2. Vukan R Vuchic(2007), “Urban Transit Systems and Technology ”,John Wiley&sons Inc
3. Vukan R Vuchic(2017),“Urban Transit Operations , Planning and Economics ”,John Wiley & sons Inc
4. MichaelD.MeyerandEricJ.Miller,"UrbanTransportation Planning–A Decision Oriented Approach",McGrawHillBookCompany,NewYork,1984
5. HobbsF.D,"Traffic Planning and Design ", Poargamon Oress
6. JohnW.Dickey,"Metropolitan Transportation Planning"—Tata McGraw Hill Publishing Company Limited,NewDelhi,1980
7. PaulH.Wright," Transportation Engineering–Planningand Design",John Wiley and Sons,NewYork,1989.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	3	3	2
CO2	2	3	3	3	3	3
CO3	3	2	3	2	3	3
CO4	3	2	3	3	3	2
CO5	3	3	2	2	2	3
Avg	**3**	**2**	**3**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high

TE3002 WATERWAYS TRANSPORTATION SYSTEM – PLANNING AND DESIGN

L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Fresh Water and Salt Water Navigation – Ocean, Currents and Tide – Canals and Waterways –Ports Types of Ships

UNIT II LOGISTICS AND MULTIMODAL TRANSPORT 9

Containers – Distribution and Collection by Road and Rail – Vehicles and Equipment used – Trade Routes- liquid cargo

UNIT III PORT PLANNING 9

Traffic Forecast, Demand, Users, Capacity – Berth occupancy – Service time – Waiting time – Principles of Planning Port Layout – Handling characteristics – Voyage Estimating

UNIT IV PORT AND TERMINAL MANAGEMENT 9

Role of ports in trade and transport – Port facility for handling liner, dry bulk and liquid trade – Basics of Port Business – Customs – Immigration, Port Health – Marine Safety – Pricing – Traffic Management in Port Premises

UNIT V INLAND WATER WAYS AND OTHER MODES OF TRANSPORT 9

Inland Water Transport – Planning, limitations and advantages – Case Studies –Pipelines – Ropeways – Beltways – other means of transport – Characteristics and Applications

TOTAL: 45 PERIODS

COURSE OUTCOME:

CO1 Understand the importance and types of waterways and navigation systems
CO2 Knowledge on the logistics applied in water transport
CO3 Planning of port and its infrastructures.
CO4 Terminal management and its economical analysis
CO5 Knowledge on other transport modes and their case studies.

REFERENCES:

1. Leslie A.Bryan, “Principles of Water Transportation”, University of Chicago Press
2. Paul H.Wright, J.Ashford Norman, “Transportation Engineering, Planning and Design”, John Wiley and Sons Inc.,1997
3. “Shipping and Inland Water Transport for Eleventh Five Year Plan” – Report by Planning Commission

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2	2	2
CO2	2	2	3	3	3	3
CO3	2	2	3	3	3	3
CO4	3	2	3	3	3	3
CO5	3	3	3	3	3	3
Avg	3	2	3	3	3	3

• 1-low, 2-medium, 3-high

TE3003 AIRPORT SYSTEM PLANNING AND DESIGN L T P C
3 0 0 3

UNIT I AIRPORT PLANNING 10

Planning of airports and its impact on metropolitan city development– Accessibility – Transport Connections – Road and Rail, Expansion – Feasibility Studies – Environmental and Social Issues – Forecasting Future Traffic – Airfield Capacity and Delay - Aircraft characteristics – Airport Site Selection

UNIT II AIRPORT COMPONENTS 10

Airport Classification, Planning of Airfield Components – Runway, Taxiway, Apron, Hangar- Passenger Terminals- Geometric design of runway and taxiways-Runway pavement Design- Difference between Highway and airport pavements- Introduction to various design methods-Airport drainage.

UNIT III AIRPORT PLANNING AND AIRLINE ECONOMICS 9

Demand driven dispatch – Airline Fleet Planning Models – Network Revenue Management – Airport Performance, Slot Issues, Hub Operation, Demand Management, Multi-airport Systems- Pricing – Privatization and Deregulation, Willingness to pay and Competitive Revenue Management

UNIT IV PASSENGER CHOICE, SCHEDULING AND FLEET ASSIGNMENT 7

Load Factor Analysis, Airline Schedule Development, Introduction to PODS Passenger Choice Models, Decision Window Model, Fleet Assignment

UNIT V CASE STUDIES 9

Multi airport system – location of airport with respect to urban growth- case studies.

TOTAL: 45 PERIODS

COURSE OUTCOME:

CO1 Students can conduct Feasibility studies and plan an airport.
CO2 Knowledge on Design of various Airport components.
CO3 Knowledge on Airport Management and economics.
CO4 Able to develop scheduling and various models for Airport management.
CO5 Students get an overall knowledge about Airport planning and Design.

REFERENCES:

1. Robert Honjeff and Francis X.Mckelvey, "Planning and Design of Airports", McGraw Hill, New York,1996
2. Richard De Neufille and Amedeo Odoni, "Airport Systems Planning and Design", McGraw Hill, New York,2003
3. Airport Planning and Systems –http://airportssystems.com/Course/index-html
4. Khanna S.K and .Arora M.G, "Airport Planning and Design", Nem Chand and Bros,1999.
5. Norman.J.Ashford, Sakleh.A Mumayiz and Paul.H.Wright, "Airport Engineering Planning Design and Development of 21st Century Airports, John Wiley and sons, New Jersey,2011.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	2	2
CO2	2	3	3	3	3	3
CO3	2	2	3	2	3	3
CO4	3	2	2	3	3	3
CO5	2	2	2	3	3	3
Avg	**2**	2	2	3	3	3

• 1-low, 2-medium, 3-high

AG3020 GEOSPATIAL TECHNIQUES L T P C
3 0 0 3

UNIT I INTRODUCTION TO REMOTE SENSING 10

Definition – Types of Remote Sensing -Components of Remote Sensing – Energy, Sensor, Interacting Body – Active and Passive Remote Sensing – Platforms – Aerial and Space Platforms – Aircraft and Satellites – Electromagnetic Radiation – EMR Spectrum - Aerial Photography and types Overlap and sidelap – stereoscopes - Flight mission – Types of satellites - Energy, Sensor, Interacting Body – Electromagnetic Radiation – Spectral signatures.

UNIT II INTRODUCTION TO GIS 10

Basic Concept and Components of GIS – Hardware and Software – Data input and output - Data Types - Spatial and non-spatial – Vector and Raster – Maps and types of maps – Map scale and importance – Geo-referencing – Map Projection – Types of Projection – Height referencing – Introduction to GPS & DGPS

UNIT III DATA STRUCTURES AND ANALYSIS 9

Digitization and Scanning - Geographic database - GIS Modelling - Raster and Vector data structures – Raster and Vector data analysis – Data storage – DEM and TIN models - Edge matching - Rubber sheeting - Buffering and overlaying techniques – Errors in database .

UNIT IV BASIC APPLICATIONS IN TRANSPORTATION 8

Highway and Railway Alignment- Bus route rationalization – Accident analysis – Applications of Aerial Photography and Satellite Imageries- Visual Interpretation and Digital Image Processing.

UNIT V ADVANCED APPLICATIONS 8

Integration of GIS,GPS and Remote Sensing Techniques – Surveying-mapping and monitoring-Intelligent Transport System (ITS) – Components and Advantages -Smart city development-

TOTAL: 45 PERIODS

COURSE OUTCOME:

CO1 Understand the concepts and principles of remote sensing
CO2 Knowledge on working principles of GIS and its interpretation
CO3 Analysis of Data Structures, buffering and overlaying techniques.
CO4 Applying the GIS techniques and image processing in transportation field
CO5 Understand application of GIS in integration to information technology applied in transport sector.

REFERENCES:

1. Srinivas M.G, "Remote Sensing Applications", Narosa Publishing House, 2001
2. Anji Reddy, "Remote Sensing and Image Interpretation", John Wiley and Sons Inc. New York, 1987.
3. Burrough P.A, "Principles of GIS for Land Resources Assessment",Oxford Publication,1994.
4. Jeffrey Star and John Ester, Geographical Information System – An Introduction, Prentice Hall Inc., Englewood Cliffe,1990.
5. Marble, D.F, Calkins, H.W and Penquest, Basic Readings in GIS, Speed System Ltd., New York,1984.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	2	3	3
CO2	2	3	3	3	3	3
CO3	2	2	3	3	3	3
CO4	2	2	3	3	3	3
CO5	2	3	3	3	3	3
Avg	**2**	**2**	**3**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high

TE3004 ANALYTICAL TECHNIQUES IN TRANSPORTATION ENGINEERING L T P C
3 0 0 3

UNIT I COMPUTATIONAL INTELLIGENT TECHNIQUES 9

Concept of fuzzy sets- basics elements of fuzzy systems; Artificial Neural Networks – Introduction-Characteristics of neural networks- Multilayered feed forward neural networks trining- validation of neural models.

UNIT II MULTI ATTRIBUTE DECISION MAKING METHODS 9

Attribute weights, Minimax method, Maximax methods, simple additive weighting method, TOPSIS.

UNIT III INTRODUCTION TO BIG DATA 9

Evolution of Big data - Best Practices for Big data Analytics - Big data characteristics - Validating - The Promotion of the Value of Big Data - Big Data Use Cases- Characteristics of Big Data Applications - Perception and Quantification of Value -Understanding Big Data Storage - A General Overview of High-Performance Architecture.

UNIT IV CLUSTERING AND CLASSIFICATION 9

Advanced Analytical Theory and Methods: Overview of Clustering - K-means - Use Cases - Overview of the Method - Determining the Number of Clusters - Diagnostics - Reasons to Choose and Cautions .- Classification: Decision Trees - Overview of a Decision Tree - The General Algorithm - Decision Tree Algorithms - Evaluating a Decision Tree - Decision Trees in R - Naïve Bayes - Bayes' Theorem - Naïve Bayes Classifier.

UNIT V DELPHI TECHNIQUES 9

Introduction – Conducting Delphi survey- Methodological consideration- selection and size of panel- Questtionaire design and scoring methods-feedback- merits and consenses.

TOTAL: 45 PERIODS

COURSE OUTCOME:

CO1 Understand the concepts of fuzzy logic and Artificial Neural Network
CO2 AnalyseMulti Attribute Decision Making Methods
CO3 To analyse and manage data clustering and management
CO4 Interpret various clustering techniques and classifications
CO5 Understand the concepts of Delphi techniques and methodologies.

REFERENCES:

1. Traffic and transportation Engineering, DusanTeodoravic and Milan Janic.
2. Mobility Pattern,Big Data and Transport Analutics, Constantinos Antoniou, Loukas Dimitriou.

CO-PO Mapping

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CO4	2	2	2	2	2	2
CO5	2	2	2	2	2	2
Avg	**2**	**2**	**2**	**2**	**2**	**2**

• 1-low, 2-medium, 3-high

TE3005 DYNAMIC SIMULATION MODELING FOR SUSTAINABLE TRANSPORTATION AND MANAGEMENT L T P C
3 0 0 3

UNIT I SYSTEMS APPROACH CONCEPT 9

System – Concepts, Theories – Classification – Models – Concept of Modeling exercises - Phases in model building process – System Approach –Dynamics Simulation (D.S) View Points with its Paradigms– Fundamentals of GPSS & Monto carlo method – Pseudo Random generators – Differences between approaches.

UNIT II MODEL CONCEPTUALISATION 9

Model Verification- Causal Loop (C.L) Diagramming Approach – Justification for links – Conceptualization and Development of Causal Loop Representations - Case Study examples in C.L diagramming in Transportation Planning – Principles of Systems and its Hierarchies.

UNIT III MODEL DEVELOPMENT AND SCENARIO ANALYSIS 9

System Dynamic Model Development - Flow Diagramming methodologies – Stocks and Rate Variable Concepts – Relevance of selection in Level and other auxiliary variables – Significance of Optimization Techniques in Simulation Modeling– Importance of Policy and Scenario Analysis.

UNIT IV APPLICATION OF SIMULATION CONCEPTS 9

Applications of GPSS - Simple queuing problems - Analysis of simulation results - Model Verification , Calibration and Validation - Replication of random conditions –Time series and forecasting analysis.

UNIT V MODELINGTRANSPORTATION SYSTEMS 9

Simulation Models - Application In Basic Population Sector for Traffic, Transportation Systems – Modeling of any traffic and Trip Forecasting systems /Productions and Service Level Quality Enhancement – Modeling of Basic Land Use and Transport system interactions- Other Relevant areas- Future traffic simulation Models.

TOTAL: 45 PERIODS

COURSE OUTCOME

CO1 Concept and Knowledge on dynamic simulation modelling with conventional modelling
CO2 Understand the model conception & design algorithm for transportation problems
CO3 Exposure in model representation with model symbols with its significance
CO4 Model verification, calibration & validation and compare it with traditional approach
CO5 Application of dynamic simulation modelling exercise to wide range of traffic and transportation issues

REFERENCES

1. Pratab Mohapatra K.Jetal.,"Introduction to System Dynamics Modeling ", University Press ,Hyderabad,1994
2. Thirumurthy A.M.(1992), " Environmental Facilities and Urban Development in India — A System Dynamics Model for Developing Countries , Academic Foundations, India.
3. Christopher A.Chung(2003),“ Simulation Modeling Handbook :A Practical Approach ”-1st Edition ,CRC Press Publication,USA
4. Winnie Daamen ,Christine Buisson ,Serge P.Hoogendoorn(2017), “ Traffic Simulation and Data : Validation Methods and Applications ”- 1st Edition,CRC Press Publication, USA.
5. CoyleR.G(2001),"System Dynamics Modelling A Practical Approach"-1st Edition ,Chapman & Hall /CRC Press Publications ,Washington D.C,USA

CO-PO Mapping

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CO3	2	3	3	3	3	3
CO4	3	3	3	2	3	3
CO5	2	3	3	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high

TE3006 COMPUTATIONAL TECHNIQUES IN TRANSPORTATION ENGINEERING

L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Introduction to systems approach - Typical transportation systems - Mathematical models. Fundamentals of simulation - Monte Carlo method - Continuous and discrete models - Simulation languages. Probability concepts - Random numbers - Pseudo random generators - Arrival patterns - Service time distributions – Manual simulation of simple queuing system

UNIT II FUNDAMENTALS OF SIMULATION 9

GPSS Fundamentals - Creating and moving transactions - Queues and facilities - Event scheduling – Standard numerical attributes – Parameters and save values - Functions - Priority - Preemption - Collection of statistics - Report preparation. Internal logic of GPSS processor - Program control statements.

UNIT III APPLICATION OF SIMULATION CONCEPTS 9

Applications of GPSS - Simple queuing problems - Inventory problems - Simulation of ports - Railway platforms and level crossings - Traffic signals. Analysis of simulation results - Model validation - Replication of random conditions - Time series analysis.

UNIT IV APPLICATION OF GENETIC ALGORITHM IN SIMULATION 9

Genetic Algorithm - Terminology in GA – Strings, Structure, Parameter string - Data Structures – Operators - Algorithm – Application in Transportation. Fuzzy Logic.

UNIT V APPLICATION OF ARTIFICIAL NEURAL NETWORKS IN SIMULATION 9

Artificial Neural Networks - Basics of ANN – Topology - Learning Processes - Supervised and unsupervised learning. Least mean square algorithm, Back propagation algorithm - Applications.

TOTAL: 45 PERIODS

COURSE OUTCOME:

CO1 Gain Knowledge on Various Types of Modeling
CO2 Knowledge on fundamentals of simulation techniques and functions.
CO3 Application of simulation techniques in transport sector, modeling and validation.
CO4 Gain knowledge on genetic algorithm in simulation and fuzzy logic.
CO5 Applications of ANN and its application in transport sector.

REFERENCES:

1. Gordon, G., System Simulation, Prentice-Hall of India,2005
2. GPSS/PC, User Manual, Minuteman Software, USA,2005
3. David E. Goldberg, Genetic Algorithms in Search, Optimisation and Machine Learning, Addison-Wesley,1989
4. ZuradaJ.M. , .Introduction to artificial neural systems., Jaico Publishers,2006

CO-PO Mapping

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CO3	2	3	2	3	2	2
CO4	3	2	2	2	2	3
CO5	2	2	3	3	2	3
Avg	**2**	**2**	**2**	**2**	**2**	**2**

• 1-low, 2-medium, 3-high

TE3007 SUSTAINABLE URBAN AND TRANSPORT PLANNING L T P C
3 0 0 3

UNIT I SUSTAINABLE URBAN AND TRANSPORT PRINCIPLES 9

Urban Sustainable Development, Methods and Tools for Sustainable Appraisal and Assessment , Future Scenarios, Integrated and inclusive planning, Sustainable Transportation – Principles indicators and its implications, Guidelines for Environmentally sound Transportation, Benefits of Sustainable Transportation- Guiding Principles

UNIT II THE URBAN BUILT ENVIRONMENT 9

Urban Form- Neighborhood component and structure, Land Use, Green and Smart cities, Compact Development, Principles of street design – complete streets, Transit planning, Road side infrastructure Planning, Transport Integrated Urban land use Planning- Planning for resilient cities

UNIT III PLANNING FOR SUSTAINABLE TRANSPORTATION PEDESTRIAN 10

Pedestrian – Planning Principles, Tools, Designs, Methods to measure success, crossings and intersections and junctions, – Equity Principle, Accessibility, Factors affecting walking- methods of evaluation- LOS- Case study- Guidelines

UNIT IV PLANNING FOR SUSTAINABLE TRANSPORTATION- CYCLE AND PUBLIC BIKE SHARING SYSTEM 8

Planning for cycle track- Network and route Planning-Urban, cycling design guideline. Public bicycle sharing system-planning design- case studies and guidelines

UNIT V PLANNING FOR SUSTAINABLE TRANSPORTATION- PUBLIC TRANSPORT, ELECTRICAL MOBILITY 9

Planning for Public Transport – Mobility and accessibility- Bus Transit Planning, Multimodal Integration- Integrating Public Transport with Footpath & Cycling facilities- IPT

TOTAL: 45 PERIODS

COURSE OUTCOME:

CO1 To be acquainted with sustainable urban transportation systems and principles.
CO2 Understand basic urban form and integrated land use planning.
CO3 Able to develop Sustainable Transportation Modes.
CO4 Knowledge on various Environmental Regulations and Acts.
CO5 Various environmental impacts of Transportation projects and guidelines to be followed.

REFERENCES:

1. Joe Ravetz, City Region 2020 – "Integrated Planning for a Sustainable Environment, 2000.Sustainable Transportation and TDM – Planning the balances, Economic, Social and Ecological objectives; Victoria Transport Policy Institute, 2007 .
2. Tumlin Jeffrey, "Sustainable Transportation Planning- Tools for Creating Vibrant", Healthy and Resilient Communities, John Wiley & Sons, 2012.
3. Larry W Canter, "Environmental Impact Assessment", McGraw Hill Publishers, 1996.
4. John Glasson, Riki Therivel, Andrew Chadwick, Introduction to Environmental Impact Assessment", 4th Edition, Routledge, New York.2012
5. World Bank; "the Impact of Environmental Assessment – A Review of World Bank Experience, Washington, 1997.
6. Bike sharing planning guide-
7. ITDP- optimizing Dockless Bike sharing for cities-
8. ITDP – Maximing micro mobility 2021
9. ITDP- Complete Streets
10. World Bank; Road and the Environment, World Bank Technical paper no. 363, Washington, 1997.
11. Scottish Natural Heritage , A handbook on environmental impact assessment, 4th Edition, Natural Heritage Management, www.snh.gov.uk., (2013)

CO-PO Mapping

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CO3	3	3	3	3	3	3
CO4	2	2	3	3	3	3
CO5	3	3	3	3	3	3
Avg	3	2	3	3	3	3

• 1-low, 2-medium, 3-high

TE3008 INTELLIGENT TRANSPORTATION SYSTEMS L T P C
3 0 0 3

UNIT I INTRODUCTION TO INTELLIGENT TRANSPORT SYSTEM 8

Introduction to Intelligent Transportation Systems (ITS) -Definition – Role and Responsibilities – Advanced Traveller Information System – Fleet Oriented ITS Services – Electronic Toll Collection – Critical issues – Security – Safety

UNIT II ITS ARCHITECTUREAND HARDWARE 9

Architecture – ITS Architecture Framework – Hardware Sensors – Vehicle Detection – Techniques – Dynamic Message Sign – GPRS – GPS – Toll Collection

UNIT III ADVANCED TRANSPORT MANAGEMENT SYSTEM 10

Video Detection – Virtual Loop - Cameras - ANPR – IR Lighting – Integrated Traffic Management – Control Centre – Junction Management Strategies- ATMS – Advanced Traveler Information Systems (ATIS)- Route Guidance – Issues -– Historical – Current – Predictive Guidance – Data Collection – Analysis – Dynamic Traffic Assignment (DTA) – Components – Algorithm-Integrated Command and Control Centre.

UNIT IV ADVANCED TRAVELLER AND INFORMATION SYSTEM 9

Travel Information – Pre Trip and Enroute Methods- Basic ATIS Concepts – Smart Route System – Data Collection – Process – Dissemination to Travelers – Evaluation of Information – Value of Information – Business Opportunities

UNIT V CASESTUDIES 9

Automated Highway Systems - Vehicles in Platoons – Integration of Automated Highway Systems. ITS Programs in the World – Overview of ITS implementations in developed countries, ITS in developing countries-Toll Management

TOTAL: 45 PERIODS

COURSE OUTCOME:

CO1 Relate the basic responsibilities and application of of ITS in fleet services & ETC etc. in the field of smart transportation

CO2 Construct the architecture frame work of ITS and working techniques of various sensors, vehicle detection & DMS

CO3 Inspect the advanced transportation management system, application of different instruments for vehicle detection & traffic data collection

CO4 Perceive the concepts of ATIS involves in smart routing, data collection, evaluation & Opportunities in business

CO5 Compile various case studies dealing with Integration of Automated Highway Systems & ITS implementations stratagies in developed countries & developing countries

REFERENCES

1. Intelligent Transport Systems, Intelligent Transportation Primer, Washington, US,2001.
2. Henry F.Korth, and Abraham Siberschatz, Data Base System Concepts, McGraw Hill,1992.
3. Turban E.,"Decision Support and Export Systems Management Support Systems", Maxwell Macmillan,1998.
4. Sitausu S. Mittra, "Decision Support Systems – Tools and Techniques", John Wiley, New York,1986.
5. Cycle W.Halsapple and Andrew B.Winston, "Decision Support Systems – Theory and Application", Springer Verlog, New York, 1987
6. ITS Hand Book 2000: Recommendations for World Road Association (PIARC) by Kan Paul Chen, John Miles.

CO-PO Mapping

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CO3	2	3	3	2	3	3
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CO5	2	2	2	3	3	3
Avg	**2**	**2**	**3**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high

TE3009 PAVEMENT REHABLITATION AND MANAGEMENT SYSTEM L T P C
3 0 0 3

UNIT I PAVEMENT MANAGEMENT PROCESS 9

Historical background – general nature and applicability of systems methodology – basic components of Pavement Management System –Network and Project level of PMS - PMS functions- planning pavement investments.

UNIT II FUNCTIONAL EVALUATION AND PERFORMANCE 9

General concepts – economic and functional evaluation – evaluation of pavement performance– pavement distresses – condition surveys – safety evaluation visual rating of distresses, image processing; pavement friction, texture depth and skid resistance -LCMS laser crack management system- PCI development-application of GIS in pavement evaluation-case studies.

UNIT III PAVEMENT STRUCTURAL EVALUATION 9

Factors affecting Structural Condition of Flexible and Rigid Pavements- Pavement Deterioration-Evaluation by Non-Destructive Tests such as FWD, Benkelman Beam Rebound Deflection, Plate Load Test, Evaluation by Destructive Test Methods, and Specimen Testing -Structural analysis of Airfield pavements

UNIT IV PERFORMANCE PREDICTION MODELS 9

Pavement performance prediction - concepts, Techniques for developing prediction models – ranking and optimization methodologies- AASHO, CRRI and HDM models – computer applications – ANN, MATLAB–deterioration modeling- Pavement prioritization techniques.

UNIT V MAINTENANCE AND REHABILITATION 9

Repair of pavement defects – types of maintenance of flexible and rigid pavements - Preservation and surface treatments - fog seals, crack sealing, slurry sealing and Overlays -Design of Overlays-Whitetopping, microsurfacing thin overlays . Use of Geo synthetics in Pavement.

TOTAL: 45 PERIODS

COURSE OUTCOME:

CO1 Apply the knowledge on methods of pavement management.
CO2 Conduct research on the functional evaluation and performance of pavements
CO3 Conduct research on the Structural performance of pavements
CO4 Apply the mathematical theories and concepts in predicting the performance of pavements.
CO5 Understand and Select various maintenance and rehabilitation methods with real time case studies.

REFERENCES:

1. Sahini M.Y., Chapman and Hall," Pavement Management for Airports, Roads and Parking Lots" , New York,1992.
2. Srinivasa Kumar.R," Pavement Evaluation, Maintenance & Management system, Universities Press India P Ltd, 2014
3. Ralph Haas, W. Ronald Hudson and John Zaniewski, Modern Pavement Management, Kreigar Publishing Company, New York,1994
4. Michael Sargious, Pavements and Surfacings for Highways and Airports, Applied Science Publishers Limited, London,1975

CO-PO Mapping

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CO3	3	3	3	2	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3
Avg	**3**	**2**	**3**	**2**	**3**	**3**

• 1-low, 2-medium, 3-high

TE3010 ENVIRONMENTAL IMPACT ASSESSMENT OF TRANSPORTATION PROJECTS

L T P C
3 0 0 3

UNIT I ENVIRONMENTAL REGULATIONS AND EIA 10

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, Coastal Regulation Zone - Ambient Air Quality and noise Standards - EIA in Project Cycle- Impact of Traffic and transport on Environment-EIA Notification- EIA process and terms of reference for EIA of transportation Projects.

UNIT II ENVIRONMENTAL IMPACT INDENTIFICATION AND PREDICTION 10

Vehicle and Traffic Noise, Ambient Noise Level, Heath Effects, Vibration – Damage to building, Exhaust Emission –Measurement of Air and Noise Pollution- Air Pollution effects on Human being, Vegetation and Animals -Data analysis and Prediction of Pollution and Impact Data – Line source emission modeling– Noise pollution prediction.

UNIT III SOCIAL IMPACT ASSESSMENT 8

Urban Growth Indicators of Environmental Quality, Energy use, Fuel Economy in Transportation, Energy Efficiency strategies - Land Acquisition- Public Consultation - Cost benefit analysis - Rehabilitation Plans

UNIT IV ENVIRONMENTAL MANAGEMENT PLAN 9

Assessment of impacts – air – water – soil – noise – biological-visual –– Cumulative Impact Assessment - Analysis of alternatives - Mitigation measures for Air and Noise Pollution – mitigating the impacts on flora and fauna - Environmental monitoring plan – Institutional arrangements- Documentation of EIA findings - Post project audit

UNIT V CASE STUDIES 8

Case studies on Environmental and social Impact assessment of Transportation projects such as Highways, Railways, Airports, Flyovers, Bridges, Ports and Harbor,

TOTAL: 45 PERIODS

COURSE OUTCOME:

CO1 Explain concepts and analysis of various motor vehicle act, pollution act and regulation zone acts.

CO2 Knowledge in Measurement of Air and Noise Pollution

CO3 Apply the knowledge of environmental quality, fuel economy in transportation & cost benefit analysis.

CO4 Explain concepts and analysis of mitigating impacts on flora and fauna & Environmental monitoring plan.

CO5 Students get an overall knowledge about environmental & social impact assessment.

REFERENCES:

1. Larry W Canter, "Environmental Impact Assessment", McGraw Hill Publishers, 1996.
2. John Glasson, Riki Therivel, Andrew Chadwick, Introduction to Environmental Impact Assessment", 4th Edition, Routledge, New York.2012
3. David Banister; "Transport Policy and Environment" Routledge,UK,, 2002
4. World Bank; "the Impact of Environmental Assessment – A Review of World Bank Experience, Washington, 1997.

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CO5	2	2	3	2	2	2
Avg	**2**	**2**	**3**	**3**	**2**	**2**

• 1-low, 2-medium, 3-high

TE3011 URBAN INFRASTRUCTURE AND ASSET MANAGEMENT L T P C
3 0 0 3

UNIT I ROAD ASSET MANAGEMENT 9

Road Asset management- designing and developing rigid (or flexible) pavement with integrated structure for underground utilities & services- Network of underground road system, need for and planning and development.

UNIT II INNOVATIVE TRANSPORT MODES 9

straddling bus concept and development (eg China)- e-rickshaws- Alternate (renewable) energy options for powering transport system- solar powered aircraft -bio-bus and its impact on solid waste management - solar-powered traffic signals and street lights- all-electric bus route with wireless charging -buses park over metal plates buried in the road.

UNIT III TELECOMMUNICATION & ITS IMPACT ON TRANSPORT 9

Commerce- e-tailing-mobile application in trade &commerce- internet-banking- internet and mobile phone in governance-services ranging from e-billing & payment for services- EB/telephone/income tax/ municipal tax & service charges/cooking gas booking &payment-booking and payment of air, train &train tickets; booking and payment of cinema tickets- teleshopping of groceries-tele-checking at airports- obtaining birth and death certificates-booking and payment for call taxis & autorickshaws; carpooling through net and mobile phones-global meets through teleconferencing- case studies

UNIT IV CLOUD-COMPUTING AND ITS IMPACTON TRANSPORT 9

The contribution of transport planning & development in conceptualization of smart cities-advances in capturing and processing traffic data in real time and managing traffic congestion- role of SCOOT & SCAT in reducing and minimizing traffic congestion- establishment of a sensor-networked and monitored city communication infrastructure, efficiently phasing traffic lights, and providing real-time guidance to drivers, can aid in reducing congestion. Digitally monitored parking spaces, able to dynamically alter prices according to available spaces, help control time spent cruising for parking.

UNIT V ROLE OF SMART CARD AND COMMUTING 9

Electronic Road Pricing (ERP) and congestion pricing- Innovative financing- carbon credit -case studies

TOTAL: 45 PERIODS

COURSE OUTCOME:

CO1 Understanding the road assets and their management techniques.
CO2 Classify the various innovative infrastructures and technologies in transport field
CO3 Understand the impact of telecommunication in transport sectors and their applications.
CO4 Explain Cloud computing and its impact in Transportation engineering
CO5 Understand the road pricing techniques and financial viability

REFERENCES:

1. International Infrastructure Management Manual. Edition2011.
2. Abu-Samra Soliman a, Integrated Asset Management System for Highways Infrastructure, LAP Lambert Academic Publishing, India, 2015
3. Asset Management for Road sector", OECD Publications Service, 2, Paris Cedex 16, France 2001.

CO-PO Mapping

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CO5	2	3	2	2	2	3
Avg	**2**	**2**	**2**	**2**	**2**	**2**

• 1-low, 2-medium, 3-high

TE3012 LOGISTICS IN TRANSPORTATION ENGINEERING L T P C
3 0 0 3

UNIT I LOGISTICS 7

Introduction to Logistics, sust logistics, surveys for urban freight planning.

UNIT II FREIGHT TRANSPORT 10

Introduction to freight transports- stakeholder- importance-planning process-freight demand model-freight forecasting- network planning- Exocometrics.

UNIT III DISTRIBUTION MANAGEMENT 10

Supply Chain – freight facility planning types location, layout, Warehouse types –Planning Vehicle Routing and Scheduling- freight distribution, freight regulation.

UNIT IV LOGISTICS MANAGEMENT 10

Logistics- Introduction, outsourcing, types – IT Application in Logistics – IT Application in Freight Management- IOT in Logistics Management – Intermodal Transportation

UNIT V ITS APPLICATION IN FREIGHT TRANSPORT 8

E tailing- E commerce, City logistics, Toll Plaza Analysis – case studies

TOTAL : 45 PERIODS

COURSE OUTCOME:

CO1 Understands basic knowledge about logistics
CO2 Knowledge on freight transport models and application
CO3 Able to manage the distribution in real time application
CO4 Managing logistics with technology.
CO5 Applying ITS in freight transport with case studies

REFERENCES

1. Blanchard S.Benjamen, "Logistics Engineering and Management", Prentice Hall, Inc, Eaglewood Cliffs, New Jersey 07632,1986
2. Coyle J.J.Bardi JE, "The Management of Business Logistics", West Publishing Company, New York,1984
3. Daganzo F.C and Newell FG, Vol.19B, No.5, pp.397-407, Physical Distribution from a Warehouse; Vehicle Coverage and Inventory Levels, Transportation Research,1985
4. Ministry of Commerce and Industry, National Logistics Policy, Govt. of India, 2022.
5. Edwin Bacht J.A., "Geography of Transportation and Business Logistics", Wm C Brown Company Publishers, Dubuque, IOWA,1970
6. Herron P.David, "Managing Physical Distribution for Profit", Harvard Business Review, 1979
7. Khanna K.K., "Physical Distribution Management", Logistical Approach, Himalaya Publishing House, Bombay,1985
8. Planning Commission, Government of India, Total Transport System Study – Report on Commodity Flows, Railways, Highways and Coastal Shipping, (Interim) by RITES, New Delhi, 1987.
9. Shapiro D. Roy and Heskett L.James, "Logistics Strategy-Cases and Concepts", Wesg Publishing Company, New York,1985

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Avg	**2**	**3**	**3**	**3**	**3**	**2**

• 1-low, 2-medium, 3-high

TE3013 ROAD SAFETY SYSTEM L T P C
3 0 0 3

UNIT I INTRODUCTION 10

Accident Scenarios – Global, National , Regional and Chennai Mega City Levels -Causes of accidents – Human factors – Vehicles – Road and its condition – Environmental Factors- Conventional methods and Inadequacies- Case studies –Intersection safety, Work zone safety.

UNIT II ACCIDENT INVESTIGATIONS AND ANALYSIS 8

Accident Data Collection - Interpreting accident data, identifying and prioritizing hazardous location, condition and collision diagram, crash reconstruction- statistical Analysis of Accidents

UNIT III BEFORE AND AFTER STUDIES 9

Accident Prediction Models –Empirical Bayees Approach – Before and After methods in accident analysis, Block spot identification and investigations, Hot spot analysis– Case Studies

UNIT IV ACCIDENT COSTING 8

Cost of Road Accidents –methods of accident costing - Economic Analysis of Road Accident Cost in India.

UNIT V ROAD SAFETY AUDIT 10

Key Elements of road safety audit, Road safety audit & Investigations, Planning stage, Design stage, construction stage, work zone safety audit- Post Construction stage.

TOTAL : 45 PERIODS

COURSE OUTCOME:

CO1 Apply the knowledge of science and engineering fundamentals in developing an efficient road safety system & conduct research pertinent to road safety and management and to communicate effectively to different stakeholders as well as engage in independent life-long learning

CO2 Explain concepts and analysis of accident data collection and studies

CO3 Knowledge in accident analysis techniques with various advanced methods.

CO4 conduct research pertinent to road accident costing and to communicate effectively to different stakeholders as well as engage in independent life-long learning.

CO5 Concepts & Significance of road safety audit and management system with case studies.

REFERENCES:

1. Martin Belchar,"Practical Road Safety Auditing", Ice Publishing, 2015
2. Ministry of Surface Transport, "Accident Investigation and Prevention Manual for Highway Engineers in India, Government of India ,2001.
3. Indian Roads Congress -IRC (2013), Ministry of Road Transport & Highways (MORTH, formerly MOST) Road Safety Audit Manual (IRC:SP-88) .
4. Geetam Tiwari, Dinesh Mohan (2016), "Transport Planning and Traffic Safety: Making Cities, Roads, and Vehicles Safety"- 1st Edition, CRC Press Publication, USA.
5. Dhillon B.S (2011), "Transportation Systems Reliability and Safety"- 1st Edition, CRC Press Publication, USA.
6. Martin Belcher, Steve Proctor and Phil Cook (2011), "Practical Road Safety Auditing"- 3rd Edition, ICE Publication, Scotland.
7. Ministry of Surface Transport (2001), "Accident Investigation and Prevention Manual for Highway Engineers in India, Government of India.
8. Martin Belcher, Steve Proctor, Phil Cook (2015), "Practical Road Safety Auditing", 3rd edition, ICE Publications, USA

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	3	2	3
CO2	3	3	3	2	3	3
CO3	3	3	2	3	3	3
CO4	3	3	3	3	2	2
CO5	2	3	2	3	2	2
Avg	3	3	3	3	3	3

• 1-low, 2-medium, 3-high

TE3014 GEOSYNTHETICS FOR PAVEMENTS L T P C
3 0 0 3

UNIT I INTRODUCTION TO GEOSYNTHETICS 9

Principles-concepts and mechanism of reinforced earth. Types of geosynthetics-functions of geosynthetics- Properties of geogrids-geotextiles-geomembranes-geo composites-mechanical properties of geogrids and geotextiles. Tensile strength parameters; laboratory tests-pullout tests-friction test on geogrids and geotextiles.

UNIT Ii APPLICATION OF GEOSYNTHETICS IN PAVEMENTS AND RAILROADS 9

Geosynthetics- interaction mechanism - subgrade separation and reinforcement-Base reinforcement, overlay stress absorption and reinforcement, multiple functions of geosynthetics in roadway applications-paved roads-base courses -pavements -unpaved roads. Geosynthetics in controlling swelling and mud pumping of ballasted railway track-Ballast pocket in railroad embankment-Ballast Stabilization.

UNIT III ENVIRONMENTAL CONSIDERATIONS AND CASE STUDIES 9

Sustainability benefits and environmental considerations for geosynthetic application-Mitigation of environmental load induced stresses. review on case studies on geosynthetics in pavement application and railroad application- Reinforced paved roads-Reinforced retain walls-Reinforced embankments

UNIT IV GEOSYNTHETICS IN SUBSURFACE DRAINAGE 9

Subgrade dewatering-Application of geosynthetics for subgrade dewatering-road base drainage-Application of geosynthetics for road base drainage. Structural drainage-geosynthetics for structural drainage. Case studies and review.

UNIT V NUMERICAL MODELLING OF REINFORCED PAVEMENTS 9

Constitutive model and input parameters for pavement materials, soil and geosynthetics- Material models and load models. 2D Idealization-Development of numerical model for typical reinforced pavement using PLAXIS 2D. Parametric study-analysis of results-stress-strain responses-permanent deformation. Validation through case studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1 Understand the mechanism of geosynthetics and pavement interaction
CO2 To augment pavement and railroad performance through reinforcement techniques
CO3 To ensure environmental compatibility of the composite systems designed
CO4 To overcome problems associated with water infiltration in pavements
CO5 To validate pavement performance through numerical modelling

REFERENCES:

1.Koerner, R.M., Designing with Geosynthetics, (Third Edition), Prentice Hall, 1997.
2.Geosynthetic Materials Association at www.gmanow.com; Handbook of Geosynthetics
3.Jewell, R.A., Soil Reinforcement with Geotextile, CIRIA, London, 1996.
4.John, N.W.M., Geotextiles, John Blackie and Sons Ltd., London, 1987.
5.Jones, C.J.F.P., Earth Reinforcement and Soil Structures, Earthworks, London, 1982.
6.PLAXIS 2D-https://communities.bentley.com.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	3	2
CO2	3	2	3	2	3	2
CO3	2	2	3	2	2	3
CO4	3	3	3	3	3	3
CO5	3	2	3	3	3	3
Avg	3	2	3	2	3	3

• 1-low, 2-medium, 3-high

TE3015 PAVEMENT GEOTECHNICS AND MATERIAL CHARACTERIZATION

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION TO PAVEMENT GEOTECHNICS 9

Pavement design and geotechnics-typical pavement types-relationship to geotechnical issues-pavement problems associated with problematic soil-behaviour of collapsible soil-expansive soil - compressible clays in pavement perspective- pavement failures due to poor subgrade soil.

UNIT II STRESSES IN SOIL 9

Theories of elastic and plastic behaviour of soil. Compressibility of soil-estimation of settlement. Determination of mechanical properties of soil-static and cyclic triaxial test on subgrade soils-Resilient modulus- resilient deformation-Modulus of subgrade reaction-CBR test- static and cyclic plate load test. Effect of lateral confinement. Functions and importance of subgrade soil properties-subgrade soil classification for highway engineering purpose.

UNIT III MATERIAL CHARACTERIZATION OF PAVEMENTS 9

Geotechnical properties of geomaterials-soils; rock; soil and rock mixtures and recycled and alternative materials for sustainable design of pavements. behaviour of compacted geomaterials-mechanism of stabilized geomaterials-lime; cement polymers and Flyash. Evaluation of geotechnical properties of soil and stabilized soil- Basic properties-Engineering properties. Characterization of swelling soil- swell tests-swell potential- Swell pressure.

UNIT IV GEOTECHNICAL INPUTS FOR PAVEMENT DESIGN 9

Required geotechnical inputs as per IRC guidelines-AASHTO design guide-NCHRP Design Guide. Physical properties- Weight volume relationship-Plasticity; Mechanical properties-CBR; R-value-Resilient Modulus-Poisson's ratio-Modulus of subgrade reaction-Interface friction-coefficient of lateral earth pressure. Thermo-hydraulic properties - Drainage coefficients-swelling parameters-frost heave parameters-soil water characteristic curve-hydraulic conductivity.

UNIT V DESIGN ALTERATIONS AND DETAILS FOR DIFFERENT PAVEMENT LAYERS 9

Base layer-requirements-stabilization and reinforcement-erodibility of bases-modified bases-reinforcement of base. Subgrade conditions-soil stabilization-mechanism and characteristics of stabilized soil-geotextiles and geogrids reinforcement. Pavement recycling and use of recycled waste. Case studies on utilization of construction and demolition wastes in Road Works-Pond ash-copper slag and flyash in embankments

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1 Understand the sensitivity of soil issues in pavement design
CO2 Understand the mechanical characterization of geomaterials through laboratory and field tests
CO3 Understand the behaviour of geomaterials with respect to pavement applications
CO4 Understand and evaluate required geotechnical inputs for pavement design
CO5 Ability to improve poor pavement base and subgrade materials through chemical stabilization and reinforcement techniques

REFERENCES

1. Khanna, S.K., Justo, C.E.G. and Veeraraghavan, A., 2015. Highway Engineering; Nem Chand and Bros., Roorkee (Revised 10th Edition).
2. Yang H. Huang, 2008. Pavement Analysis and Design; Pearson Prentice Hall, USA
3. Course syllabus: Geotechnical Aspect of Pavement Required Textbook and Reference Materials: Geotechnical Aspects of Pavements - Reference Manual / Participant Workbook (Publication No. FHWA NHI-05-037)D
4. Iqbal H. Khan A text book of Geotechnical Engineering
5. CRAIGS SOIL MECHANICS, 8TH EDN-J A-Knapett and R.F.Craig
6. Suzanne Simard and Mary Austin et al Soil stabilization principles and practice\

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2	2	2
CO2	3	3	3	3	2	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	2
CO5	3	2	3	3	3	2
Avg	3	3	3	3	3	2

• 1-low, 2-medium, 3-high

TE3016 OPTIMIZATION METHODS IN TRANSPORTATION LT P C
3 0 0 3

UNIT I LINEAR PROGRAMMING 9

Introduction to Operations Research – assumptions of linear programming problems - Formulations of linear programming problem – Graphical method

UNIT II ADVANCES IN LINEAR PROGRAMMING 9

Solutions to LPP using simplex algorithm- Revised simplex method - primal dual relationships – Dual simplex algorithm - Sensitivity analysis

UNIT III NETWORK ANALYSIS – I 9

Transportation problems -Northwest corner rule, least cost method,Voges's approximation method - Assignment problem -Hungarian algorithm

UNIT IV NETWORK ANALYSIS – II 9

Shortest path problem: Dijkstra's algorithms, Floyds algorithm, systematic method - minimum spanning tree, maximum flow

UNIT V NETWORK ANALYSIS – III 9

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: To formulate linear programming problem and solve using graphical method.
CO2: To solve LPP using simplex method
CO3: To formulate and solve transportation, assignment problems
CO4: To solve project management problems
CO5: To solve scheduling problems

REFERENCES:

1. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010
2. Hitler Libermann, Operations Research: McGraw Hill Pub. 2009
3. Pant J C, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Pannerselvam, Operations Research: Prentice Hall of India 2010
5. Taha H A, Operations Research, An Introduction, PHI, 2008

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	1	2	2
CO2	1	1	1	1	2	2
CO3	2	1	1	2	2	2
CO4	2	1	1	2	2	2
CO5	2	1	1	2	2	2
Avg	2	1	1	2	2	2

• 1-low, 2-medium, 3-high