SYLLABUS FOR

I semester

M. Tech.

(TRANSPORTATION ENGG. &

MANAGEMENT)

Sub. Code	**N1CTMMAT**								
Course Title	**Applied Statistics for Transportation Engineering**								
Course Type	**BSC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	3
Contact Hrs./Week	3	0	0	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	39	0	0	0	0	0	0	SEE Marks	50
Credits	3								
Total Contact Hrs.	**39**							Total Marks	100

Course Objective: The objective of this course is to introduce the concepts and applications of probability and statistics in transportation engineering systems. The focus will be on applications and concepts, with less emphasis on proofs and theory.

Course Outcomes (COs): At the end of this course, the student will be able to:	
CO1	Adopt suitable sampling method and evaluate descriptive statistics.
CO2	Conceptualize and identify real word events as a function of discrete/continuous distributions.
CO3	Study relationships between various factors using regression and analysis of variance.
CO4	Evaluate multi-variate data using principal component analysis and time series analysis.
CO5	Evaluate sample data using different sampling distributions.
CO6	Formulate transportation related optimization problems and solve it using different optimization techniques.

Unit-1

Introduction and Sampling Techniques: Role of statistical thinking, data collection, Numerical and graphical summary of data, Frequency distribution; Measure of Central tendency and dispersion – Mean and Standard deviation; Standard error, Skewness; Kurtosis; Graphical summary using different plots; Definitions - Simple random sampling; Stratified sampling; Systematic sampling; Applications in Traffic and Pavement Engineering. **8 Hrs.**

Unit-2

Probability: Laws of Probability; Conditional probability and Independent events; Distributions: Binomial, Poisson, Exponential, Gamma and Normal distributions; Fitting of distributions; Chi-square test for goodness-of-fit; Applications in Transportation Engineering. **8 Hrs.**

Unit-3

Regression and Correlation: Linear regression and correlation; Multiple regression analysis, correlation; Central value; Standard error of estimate; Analysis of Variance; Multi-Variate Data Analysis: Types of data. **7 Hrs.**

Unit-4

Simple estimate of Standard deviation, Dispersion, Variance and covariance; Correlation matrices; Principal component analysis; Time series analysis - Introduction, Moving average. Applications in Transportation and Pavement Engineering. **8 Hrs.**

Unit-5

Exact Sampling Distributions: Chi-square distribution; Student's T-distribution; Snedector's F-distribution. Types of T tests: One sample T test, Independent two sample T test and Paired T test; Applications in Traffic and Pavement Engineering problems. **4 Hrs.**

Optimization Techniques: Formulation, Solutions - Simplex method, Big-M method, Two Phase Simplex method; Applications in Transportation Engineering. **4 Hrs.**

TEXTBOOKS:

1	Benjamin, J. R. and C. A. Cornell (1970).	"Probability, Statistics, and Decision for Civil Engineers", Dover Publications; Reprint Edition, 2014
2	Kumar Moluguram and G Shanker Rao	"Statistical Techniques for Transportation Engineering", B S Publications, 2017
3	Dr. L.R. Kadiyali	"Traffic Engineering and Transport planning", Khanna Publishers, 9th Edition, 1999

REFERENCE BOOKS:

1	Gupta, S.C and Kapoor K.V.	**"Fundamentals of Mathematical Statistics",** Sultanchand.1978
2	Jay Devore	**"Probability and statistics for Engineering and sciences",** 8th Edition, Cenege Publication., 2012
3	Simpson & Kafks,	**"Basic Statistics",** Oxford & IBH Calcutta, 1969.
4	N. T. Kottegoda, Renzo Rosso,	**"Applied Statistics for Civil and Environmental Engineers"**, Blackwell Publishing Ltd, 2008
5	Ang, A. H. and Tang, W. H. (2007).	**"Probability Concepts in Engineering: Emphasis on Applications in Civil & Environmental Engineering",** Wiley, 2007

Sub. Code	**N1CTM01**								
Course Title	**Pavement Materials**								
Course Type	**IPCC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	4
Contact Hrs./Week	3	0	2	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	39	0	26	0	0	0	0	SEE Marks	50
Credits	3		1						
Total Contact Hrs.	**65**							Total Marks	100

Course Objective: The objective of this course is to introduce the student to different materials used in pavement construction, designing of bituminous and cement concrete mixes and the need & use of alternate/marginal materials in pavement construction.

Course Outcomes (COs): At the end of this course, the student will be ableto	
CO1	Assess the suitability of various conventional and modified construction materials for pavement application.
CO2	Design, characterize and analyze the bituminous mixes by Marshall method.
CO3	Design the bituminous mixes by Superpave method.
CO4	Design the cement concrete mix for CC pavement and assess its strength requirement.
CO5	Describe the need and use of various alternate/sustainable materials for pavement construction.

Unit-1

Aggregates: Requirements, properties and tests on road aggregates for unbound and bound granular sub-base and base, design gradation for unbound and bound pavement layers.

Bituminous binders: Conventional and modified binders, criterion for selection of different binders

Bituminous Emulsions and Cutbacks: Application in pavements. **8 Hrs.**

Unit-2

Bituminous Mixes: Mechanical properties: Resilient modulus, dynamic modulus and fatigue characteristics of bituminous mixes. Dense and open textured mixes, flexibility and brittleness, common mechanical tests, bituminous mix design methods and specifications. Characterization of bituminous mixes for pavement design

Weathering and Durability of Bituminous Materials and Mixes: Tests in weathered bituminous materials, Adhesion, failure, mechanism of stripping, tests and methods of improving adhesion. **8 Hrs.**

Unit-3

Performance based Bitumen Specifications: Superpave physical test using rotational viscometer, dynamic rheometer, binder beam rheometer, direct tension tester for asphalt binders, superpave asphalt binders specifications based on permanent deformation, fatigue cracking, low temperature cracking, selection of superpave binder grades.

Superpave mix design method: selection of aggregate blend, Superpave gyratory compaction, compaction of samples, selection of optimum asphalt content, superpave mix design example problems **9 Hrs.**

Unit-4

Cement Concrete for Pavement Construction: Materials, requirements, and design of mix for CC pavement, IRC and IS specifications and tests, joint filler and sealer materials. **7 Hrs.**

Unit-5

Alternate/Sustainable Pavement Materials: Need, Scope for use of alternate/sustainable materials in pavement construction, various alternate/sustainable pavement materials and their requirement for road application. **7 Hrs.**

Lab Component:

1. Basic characterization of soil for subgrade application 8 Hrs.
2. Basic characterization of aggregates for granular and wearing courses 8 Hrs.
3. Basic characterization of bitumen 6 Hrs.
4. Basic characterization of cement 4 Hrs.

TEXTBOOKS:

1	S.K. Khanna, C.E.G. Justo and A. Veeraragavan	**"Highway Engineering"**, Nem Chand and Bros. Roorkee, 10th Edition, 2018.
2	Prithvi Singh Kandhal	**"Bituminous Road Construction in India",** PHI, 2016.

REFERENCE BOOKS:

1	Robert N Hunter, Technical Editor	Shell Bitumen Handbook, Thomas Telford Publishing, USA, 1990
2	Yoder E J and Witczak, M.W.	"**Principles of Pavement Design"-** Wiley India Pvt Ltd., 2nd Edition, 2011.
3	S K Khanna, C E G Justo and A Veeraragavan, **"Highway Materials and Pavement Testing",** Nem Chand & Bros, 2013.	
4	**"Asphalt Mix Design Methods – Manual Series 2",** 7th Edition, Asphalt Institute, 2015.	
5	**"Asphalt Mix Design Methods – Manual Series 2",** 7th Edition, Asphalt Institute, 2015.	
6	Relevant **IS and IRC** publications	

Sub. Code	**N1CTM02**								
Course Title	**Traffic Engineering and Geometric Design**								
Course Type	**PCC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	4
Contact Hrs./Week	3	2	0	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	39	26	0	0	0	0	0	SEE Marks	50
Credits	3	1							
Total Contact Hrs.	**65**							Total Marks	100

Course Objective: The objective of this course is to introduce the geometric design aspects of urban and rural highways along with expressways; different aspects of traffic engineering including various traffic studies, analysis, improvement measures, regulations and management techniques. Also, the student will acquire on-site experience of collecting traffic data.

Course Outcomes (COs): At the end of this course, the student will be ableto:	
CO1	Design the geometric design features of highways as per IRC guidelines.
CO2	Design of geometric elements of intersections as per IRC guidelines.
CO3	Describe traffic stream characteristics.
CO4	Describe the studies related to parking, origin and destination, accident and toll operation.
CO5	Describe various traffic regulatory measures and traffic management techniques.

Unit-1

Geometric Design: Introduction, functional classification of highways, cross sectional elements, locational design, design controls and criteria, elements of design, geometrics of site distance, stopping and passing site distance, intersection site distance, widening section design, Horizontal alignment, Vertical alignment, Numerical examples.

Intersections: Categories of intersections - uncontrolled, signalized and rotary intersections, characteristics, intersection and signal control, types of intersection controls, critical aspects of operation, conflict areas of intersections. **12 Hrs.**

Unit-2

Design considerations and objectives, two - way stop controlled intersection, all-way stop controlled intersection, signalized intersection, capacity of rotary intersection, numerical examples. Channelization, unchannelized and channelized intersections. At-grade intersections, grade separated intersections, types of interchanges, ramps – characteristics.

13 Hrs.

Unit-3

Introduction to Traffic Engineering: Traffic characteristics - Road user and vehicular characteristics; Traffic measurement procedures - Volume measurement, data analysis, concepts of ADT and AADT, prediction of traffic growth, design hourly volume and its significance; Concept of PCU, capacity and Level of Service (LOS); Speed measurements: Speed distribution, 15^{th}, 85^{th} and 98^{th} percentile speeds; Speed and delay analysis - Moving car observer method - Estimating the travel time, Running and Journey speeds, Numerical examples.

Traffic Flow Characteristics: Fundamental parameters and relations of traffic flow, speed and density; space mean speed, time mean speed, time head way, space head way; Relationship between variables, Fundamental diagram of traffic flow, Traffic stream models – Linear relationship between speed and concentration - Greenshield's model.

Skill Development Activities / Field Studies: Traffic volume data collection at mid-block and at a junction; Spot Speed studies at mid-block; Moving car observer method – Delay, Running speed, Journey speed. **14 Hrs.**

Unit-4

Specialized Traffic Studies: Parking studies - Inventory, Characteristics, Types of parking survey, On and Off street parking; Origin and Destination studies - Objectives, Survey methods, Presentation of the data; Accident studies - Factors affecting accidents, Data collection, Remedial measures, Numerical examples; Toll operation studies – Types of toll collection, Methods, Terminologies, Optimum number of toll booths, Numerical examples; Pedestrian studies – Terminologies, Factors affecting pedestrian demand, Data collection methods.

Skill Development Activities / Field Studies: On-street and Off-street Parking studies; Pedestrian studies; Analysis of accident data.

14 Hrs.

Unit-5

Traffic Regulation and Management: Principles of Regulation - Regulation on vehicles, drivers, parking; Traffic signs - Regulatory, Warning and Informatory signs; Principles of traffic signal - Cycle length, Green phase, Red phase, Lost time, Fixed and Traffic actuated signals, Design of Cycle length of fixed time signal by Webster's method and IRC method, Numerical examples; Travel demand management; Traffic management techniques - Restrictions on turning movements, One way streets, Tidal flows, Exclusive bus lanes, Closing side streets. **12 Hrs.**

Self-Study: Students should study road alignment drawings and analyze the geometric design features in detail. They should make site visits to different intersections to know practical traffic stream characteristics. Student should witness various traffic regulatory measures and management techniques adopted in urban and rural roads.

TEXTBOOKS:

1	C.Jotin Khisty and B.Kent lall	**"Transportation Engineering: An Introduction",** PHI Learning Pvt. Ltd., 3rd Edition, (2002).
2	C.S. Papacostas	**"Fundamentals of Transportation Engineering",** Prentice-Hall of India Private Limited, New Delhi,3rd edition 2002.
3	Dr. L.R. Kadiyali	**"Traffic Engineering and Transport Planning",** Khanna Publishers, 9th Edition, (1999).

REFERENCE BOOKS:

1	Fred L. Mannering, and Scott S. Washburn	**"Principles of Highway Engineering and Traffic Analysis",** , Jhon WILEY Publishers, 7th edition, 2019
2	James H. Banks	**"Introduction to Transportation Engineering",** McGraw-Hill Education, 2nd Edition, 2001
3	Martin Wohl and Brian V. Martin	**"Traffic system Analysis",** McGraw-Hill, 1967
3	Relevant **IRC** codes	

Subject Code	**N1CTM03**								
Course Title	**Pavement Construction, Equipment and Technology**								
Course Type	**PCC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	3
Contact Hrs./Week	2	2	0	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	26	26	0	0	0	0	0	SEE Marks	50
Credits	2	1	0						
Total Contact Hrs.	**52**							Total Marks	100

Course Objective:

- To introduce the concepts of various equipment, their working mechanism, functions and applications. Further, selection of equipment based on total owning cost will be understood.
- To introduce the concept of mass-haul concept related to earthwork and how economically the earthwork can be achieved using the mass-haul concept. The importance of type of equipment in achieving the earth work during road construction will be enumerated.
- To introduce the methodology adopted in the construction of base and sub-base layers with major focus on most widely used granular sub-base and wet-mix macadam layers of pavements confirming to the relevant Indian code of practices.
- To introduce state-of-the-art of asphalt paving, including plant operations, transportation of materials, surface preparation, laydown, and compaction
- To present current recommendations and guidelines on design and construction details for concrete pavements.

Course Outcomes (COs): At the end of this course, the student will be ableto	
CO1	Independently carry out investigation to solve practical problem.
CO2	Communicate and write technical documents.
CO3	Showcase a degree of mastery of the subject.
CO4	Think and solve pavement related problems and arrive at feasible/optimal solutions.
CO5	Apply modern engineering tools, equipment to evaluate and predict complex pavement engineering problems.
CO4	Think and solve pavement related problems and arrive at feasible/optimal solutions.
CO5	Apply modern engineering tools, equipment to evaluate and predict complex pavement engineering problems.

UNIT-1

Equipment Management: Selection of equipment for construction of different layers of pavements; Equipment economics – salvage value, owning cost, and operating cost.

Equipment for Earthwork: Equipment type: Hauling, Dozers, Excavators, Loaders, Hauling units, and Graders; Equipment for different layers of road construction: production capacity, factors effecting the production.
Specifications mentioning the choice of equipment for different activities of road construction [MoRT&H, IRC, IS]. **10 Hrs.**

UNIT-2

Subgrade construction: Mass-haul concept; construction of embankments and cuts for roads; preparation of subgrade and the corresponding quality control tests.
Construction of granular layers: Specifications and steps involved in the construction of GSB, WMM, and the corresponding quality control tests. **10 Hrs.**

UNIT-3

Hot-mix asphalt (HMA) facilities: Typical layout – Drum mix and Batch mix facilities; Drum mixers- Aggregate feed, Drum, Burners, Drying and Heating process; Asphalt cement injection and fines feeder system; Air quality control system - Primary collectors, wet collectors, and fabric filters .
HMA Transportation: Transportation vehicles – End dump vehicles, bottom dump vehicles; Truck loading procedures; protection during haul; Factors affecting truck cycle. **12 Hrs.**

UNIT-4

Pavers: Principles of asphalt pavers; Mix placement – Tractor unit; Screed unit; Automatic screed controls.
HMA Compaction: Compaction equipment – Steel-wheeled rollers, Pneumatic tired rollers, Vibratory steel-wheeled rollers; Rolling patterns. **10 Hrs**.

UNIT-V

Construction of Cement Concrete Pavements: Ready mix concrete – Materials feeding; Concrete pavement type selection; construction considerations - Subgrade, Base preparation, Joints, Paving, Concrete placing and spreading, consolidation, post paving, finishing, texturing, curing and opening to traffic, Joint sawing and sealing, smoothness. **10 Hrs.**

TEXT BOOKS:

1	Peurifoy R L and Clifford J S	**"Construction Planning Equipment and Method",** 8th Edition, McGraw Hill Book Co Inc, 2010.
2	S C Sharma	**"Construction Equipment and its Management",** Khanna Publishers, 2002.

REFERENCE BOOKS:

1	Freddy L Roberts,	**"Hot Mix Asphalt Materials, Mixture Design and Construction",** National Asphalt Pavement Association, Research and Education Foundation, 2nd Edition, Maryland, USA, 1996
2	**"Specifications for Road and Bridge Works, Ministry of Road Transport and Highways"** published by Indian Roads Congress, New Delhi, 5th Revision, 2013.	
3	Relevant **IRC** codes and **MoRTH** Specification	

Sub. Code	**N1CTM04**								
Course Title	**Pavement Geotechniques**								
Course Type	**PCC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	3
Contact Hrs./Week	2	2	0	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	26	26	0	0	0	0	0	SEE Marks	50
Credits	2	1							
Total Contact Hrs.	**52**							Total Marks	100

Course Objective: The objective of this course is to introduce the student to the fundamental aspects of soil mechanics, soil exploration, compaction, stresses in soils, shear strength, permeability stability analysis of slopes with the background of transportation structures.

Course Outcomes (COs): At the end of this course, the student will be able to	
CO1	Describe the various basic properties of soil including classification and compaction necessary for pavement engineering along with the relevant guidelines.
CO2	Evaluate the stresses induced in soils by Boussinesq's, Westergaard's and Burmister's analysis.
CO3	Evaluate the shear strength of soil and analyze the stability of slopes under different soil conditions.
CO4	Evaluate permeability characteristics of soil for pavement application.
CO5	Describe the sub-soil exploration techniques and prepare the investigation report.
CO6	Describe the methodology adopted in the excavation and construction works for embankments and roads.
CO7	Describe the scenario demanding special attention for subgrade and design drainage system.

Unit-1

Introduction: Soil Mechanics applications to Highway / Infrastructure Engineering. Soil formations, Types, Regional Soil deposits of India, Index properties, their determination, importance, various soil classification systems, HRB classification, problems on these.

Soil Compaction: Introduction, Lab Tests, Factors affecting, Structure & Engineering behavior of compacted cohesive soil, Field compaction specifications, Field compaction control, Different types of Equipment used for compaction, their choice. **10 Hrs.**

Unit-2

Elements of elasticity, equations of equilibrium (rectangular & polar) in 2D & 3D, stress function, Boussinesq's and Westergaard's stress analysis, Isobars, Stresses for line, strip, circular, rectangular, triangular and embankment loading, Burmister's analysis for stress in two- layered soils.

Shear strength of Soil: Introduction, Importance, Measurements, shear strength of clay, Sand, Elastic properties of soil – Tangent, Secant modulus, Stress – Strain curves, Poisson's ratio, Shear Modulus.

12 Hrs.

Unit-3

Stability of slopes: Introduction, Types, Different methods of analysis of slopes for Øu = 0 & C-Ø soil, Location of most critical circle, Earth dam slopes stability, Taylor's stability number. Effect of Earthquake Force, problems on above.

Permeability of Soil: Darcy's Law, Validity, Soil-water system, Types, Determination of permeability, problems. **10 Hrs.**

Unit-4

Site Investigation: Introduction, Planning exploration programmes, Methods, Samplers, SPT, Subsoil investigation Report, Geophysical methods.

Excavation for Roadway and Drains: Scope, Classification of Excavated material, Construction Operations, Plying of Construction Traffic, Preservation of Property, Preparation of Cut Formation, Finishing Operations, Measurements for Payment, Rates.

Embankment Construction: Scope, Materials and General Requirements, Construction Operations, Construction of Embankment and Subgrade under Special Conditions.

10 Hrs.

Unit-5

Special attention for subgrade condition: Problematic soils, compressible &collapsible soils, swelling, subsurface water, frost-susceptible soils.

Surface drainage, Sub-surface drainage, methods, Design of subsurface drainage system. Base layer requirement-erodibility of bases, bound bases, modified or treated bases, base reinforcement **10 Hrs.**

TEXTBOOKS:

1	Donald P. Coduto, Man-chu Ronald Yeung, William A. Kitch	**"Geotechnical Engineering Principles and Practices",** Pearson, 2nd Edition, 2011
2	Braja M Das	**"Advanced Soil Mechanics",** 4th Edition, 2014, McGraw Hill Book Company
3	Dr. P. Purushothama Raj	**"Ground Improvement Techniques",** 2nd Edition, Laxmi Publications (P) Ltd., 2016

REFERENCE BOOKS:

1	Graham Branes	**"Soil Mechanics",** Principle and Practice, 3rd Edition, 2010
2	**"Geotechnical Aspects of Pavements',** Reference manual", US department of transportation, Publication No: FHWA NHI-05-037, Federal Highway Administration, May 2006, NHI course no:132040.	
3	**"Soil Mechanics for Road Engineers",** HMSO, London, 1952.	
4	**"Specifications for Road and Bridge Works, Ministry of Road Transport and Highways**" published by Indian Roads Congress, New Delhi, 5th Revision, 2013.	

Sub. Code	**N1CTME11**								
Course Title	**Construction Project Management**								
Course Type	**PEC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	3
Contact Hrs./Week	2	2	0	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	26	26	0	0	0	0	0	SEE Marks	50
Credits	2	1							
Total Contact Hrs.	**52**							Total Marks	100

Course Objective: The objective of this course is to introduce the student to application of project management in construction projects using structured strategies, tactics and tools for planning construction projects, scheduling the activities using network diagrams. It also addresses various types of contracts and associated tasks used in construction projects, safety, risk and quality management aspects in reference to construction projects.

Course Outcomes (COs): At the end of this course, the student will be able to	
CO1	Describe the elements of a project and the phases of project life cycle and applying project management principles to develop WBS for various projects.
CO2	Develop schedules with the help of different scheduling techniques and network diagrams considering uncertainty in a project.
CO3	Allocate resources to a construction project considering the importance of smoothening and levelling.
CO4	Select materials, vendors and participants according to contractual terms and often set the project timeline and also to help develop the client proposal and identify breaches of contract.
CO5	Highlight the scope of risk and safety management on site and analyze the statistical quality control process of a construction project

Unit-1

Project: Introduction, Project categories, Characteristics of a Project, Project life cycle phases, Function of Project Management

Project Planning: Scope, Planning process and its objective, Types of project plan, Resource planning, Breakdown structures, duration estimation, quantity take-off, activity based costing. **10 Hrs.**

Unit-2

Project Scheduling: Introduction, Precedence network analysis (A-O-A network, A-O-N network), Logic diagram, Construction Scheduling techniques like CPM and PERT, LOB technique and linear scheduling. Float and its implication on project schedule. Use of leads and lags in logic diagrams. Resource allocation, Resource smoothening and resource leveling and related problems. **12 Hrs.**

Unit-3

Contract Management: Definition, Types of contracts: Classification Based on – Tendering Process, Economic Consideration, Tasks Involved; Main and Sub Contracts, Features, Merits, Demerits, Applicability of the various types of contracts, FIDIC and KTPP guidelines on contract management.

Breach of contract: Definition and Classification, Common Breaches by – Principal, Contractor, Damage Assessment, Claims for Damages, Quantum Meruit, Force Majeure or Frustration.

Dispute resolution: General, Methods for dispute resolution – Negotiations, Mediation, Conciliation, Dispute Resolution Boards, Arbitration, Litigation/Adjudication by courts. **10 Hrs.**

Unit-4

Safety Management: Construction Safety Engineering and Management: meaning and scope, Technological aspects, Organizational aspects, Behavioral aspects, Safety rules in Construction, Safety remedies for common hazards, Safety in Use of Construction equipment, ISI Standards for safety for building and Civil Engineering Projects.

Risk Management: Introduction, Risk Management in Construction Industry, key terms and definitions, Risk Identification, Risk Analysis and Evaluation, Risk Response and Monitoring, Risk Management misconceptions. **10 Hrs.**

Unit-5

Project Quality Management: Introduction, Elements of quality, Quality Assurance, Quality Control, Quality planning, quality audit, Quality Checklists, Total Quality Management: Philosophy (Deming, Juran, Crosby, Taguchi), TQM Tools: An overview of Flowcharts, Histogram, Pareto diagram, Scatter diagram, Control charts, Introduction to ISO 9000 quality systems, ISO 14001 quality systems. **10 Hrs.**

TEXTBOOKS:

1	Jimmie W. Hinze	**"Construction Planning and Scheduling",** 4th Edition, (2011)
2	Smith, Curie and Hancock	**"Common Sense Construction Law",** John Wiley & Sons, 4th Edition, 2009.

REFERENCE BOOKS:

1	Frank Harris and Ronald McCaffer	**"Modern Construction Management",** Wiley-Blackwell, 7th Edition, 2013
2	Denny McGeorge and Patrick Zou	**"Construction Management: New Directions**", 3rd Edition, Wiley Black Publication, Wiley-Blackwell, 2012.
3	Saurav Kumar Soni	**"Construction Management and Equipment",** S K Kataria & Sons, 1st Edition, 2015

Sub. Code	**N1CTME12**								
Course Title	**Road Safety and Management**								
Course Type	**PEC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	3
Contact Hrs./Week	2	2	0	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	26	26	0	0	0	0	0	SEE Marks	50
Credits	2	1	0						
Total Contact Hrs.	**52**							Total Marks	100

Course Objective: The objective of this course is to introduce the student to aspects of road safety, statistical analysis of accident data, road safety audit, crash reconstruction and mitigation measures.

Course Outcomes (COs): At the end of this course, the student will be able to	
CO1	Describe the concept of road safety and safety management system.
CO2	Perform statistical analysis of crash data and arrive at proper inferences.
CO3	Describe the key components of road safety audit.
CO4	Evaluate crash influencing parameters and arrive at proper reconstruction methodologies.
CO5	Describe the various mitigation measures for prevention of crashes.

Unit–1

Introduction to Safety: Road crashes, Trends, causes, Collision and Condition diagrams, Highway safety, Human factors, Vehicular factors.

Road Safety Management System: Multi-causal dynamic systems approach to safety, crash vs accident, road safety improvement strategies, elements of a road safety plan, Safety Data Needs. **10 Hrs.**

Unit–2

Interpretation and Analysis of Crash Data: Crash data, analysis, , Advanced statistical methods, Before-aftermethods of analysis, Black Spot Identification and Investigations, Crash data modeling - Case Studies.

10 Hrs.

Unit–3

Road Safety Audits: Key elements of a road safety audit, stages of audit, work zone, vulnerable zone, school zone, methods for identifying other hazardous road locations, road reconstruction safety audit, crush risk assessment programs, case studies.

10 Hrs.

Unit–4

Crash Reconstruction: Basic physics related to crash reconstruction,speed for various skid, friction, drag and acceleration scenarios, variables involved in jump and flip crashes, variables involved in pedestrian crashes.

Mitigation measures: Safety measures related to Engineering – Visual guidance to driver, road reconstruction, channelization, road signs; Safety measures related to enforcement – speed control, training and supervision, medical check; **Safety measures related to** education – Safety drive, education to road users, emerging traffic management measures

12 Hrs.

Unit–5

Crash prevention by better planning, and design of roads, Crash counter measures, Highway operation and crash control measures, Highway Safety measures during construction, Highway geometry and safety, Geometric Design Consistency and Safety measures. **10 Hrs.**

TEXTBOOKS:

1	Ogden, K. W	**"Safer Roads: A Guide to Road Safety Engineering",** Avebury Technical, 1996
2	Babkov, V.F.	**"Road conditions and Traffic Safety",** MIR, publications, Moscow - 1975.
2	Ezra Hauer	**"Observational Before-After Studies in Road Safety",** Pergamon Press, 1997 (reprinted 2002)
3	Institute of Transportation Engineers (ITE)	**"The Traffic Safety Toolbox: A Primer on Traffic Safety",** ITE, 1999
4	J. Stannard Baker	**"Traffic Collision Investigation",** Northwestern University Center for Public Safety, 2002

REFERENCE BOOKS:

1	Leonard Evans	**"Traffic Safety",** Science Serving Society, 2004
2	Popkess C. A	**"Traffic Control and Road Accident Prevention",** Chapman and Hall, 1997
3	Lynn B. Fricke	**"Traffic Accident Reconstruction",** Northwestern University Center for Public Safety, 1990
4	Martin Belcher, Steve Proctor and Phil Cook	**"Practical Road Safety Auditing",** ICE Publishing, 2015
5	Becky P. Y. Loo and Tessa Kate Anderson	**"Spatial Analysis Methods of Road Traffic Collisions",** CRC Press, 2015

Sub. Code	**N1CTME13**								
Course Title	**Airport Planning and Design**								
Course Type	**PEC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	3
Contact Hrs./Week	2	2	0	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	26	26	0	0	0	0	0	SEE Marks	50
Credits	2	1							
Total Contact Hrs.	**52**							Total Marks	100

Course Objective: The objective of this course is to introduce the student to the various aspects of airport planning, design of airport infrastructure including terminals, runways, taxiways, airfield pavement and drainage, various navigational aids, safety measures and environmental impact of airports.

Course Outcomes (COs): At the end of this course, the student will be ableto	
CO1	Describe the various aspects of airport planning.
CO2	Design the various components of an airport including terminals, runways and taxiways.
CO3	Design the airfield pavement structure and overlay and describe the standard method for airfield pavement evaluation.
CO4	Describe the various aids used in airport for uninterrupted service and perform drainage design and analysis.
CO5	Describe the various aspects in connection with airport safety including

Unit-1

Airport Planning

Structure and Organization of airport: Introduction, Types of airports, Aviation organizations: functions and responsibilities, Layout of airport, Different elements in the airport: terminal building, land side, air side.

Aircraft characteristics: Physical, operational and performance characteristics, Relation between aircraft characteristics and elements of airport, Classification of airports as per ICAO and FAA.

Air traffic management: Air traffic control, Airspace, Air traffic separation rules, Navigational aids, Signals and ground communication.

Airport planning studies: Site selection, Planning surveys, System plan, Master plan and Project plans, Level of data requirement for various phase of planning.

Forecasting aviation demand: Forecasting levels, Methods adopted in forecasting demand, Forecasting for various phases of planning.

12 hrs.

Unit-2

Design of Airports

Introduction: Terminal design, Geometric Design, Structural and functional design of pavements.

Terminal design: Function and requirements of terminal, Design considerations, Level of service, Distribution Concepts, Terminal configurations, Vertical distribution, Passenger Queuing analysis, Apron gate system, Aircraft parking configuration, Apron layout and utilities.

Geometric Design: Introduction to design standards, Design considerations,

Runways: Width, Configuration, Orientation, Capacity, Length, Geometric specifications for runways, Runway approach classification, Transverse and Longitudinal profile, Cross-sections, Runway safety zones, Obstacle limiting surface, Runway Strip, Runway end safety area, Obstacle free zones,

Taxiways: Width, Length, Separation requirements, Rapid exit taxiways: design and spacing, Transverse and longitudinal profile, Aprons, Isolation Bays, Design examples and problems.

12 hrs.

Unit-3

Structural Design of Airfield Pavements: Design standards, Design Considerations, Types of airfield pavements and their composition, Factors affecting pavement design, Design methodology, Joints in airfield pavements, Airfield pavement evaluation, Overloading, Design of overlays for airfield pavements, Standard Test Method for Airport Pavement Condition Index Surveys, Design examples and problems. **10 hrs.**

Unit-4

Airport Drainage: Importance of drainage, Design methodology, Estimation of runoff, Surface and subsurface drainage, Typical layout of drains, Drainage design and analysis.

Visual and Navigational Aids: Runway and taxiway marking, Runway and taxiway lighting, Requirements of marking and lighting, Approach guidance, Glideslope, Localizers, VASI, PAPI. **10 hrs.**

Unit-5

Airport Safety: Security requirements and planning, Aircraft accidents, Classification of aircraft accidents, Causes and remedial measures, Case studies.

Environmental Impact: Air pollution, Noise pollution, Flora and fauna, Land development and use, Standards for environmental impact assessment for airports. **8 hrs.**

TEXTBOOKS:

1	Horonjeff, R McKelvey. F.X., Sproule. W.J., Young. S.B.	**"Planning and Design of Airports"**, 5th Edition, McGraw Hill, ISBN: 978-0-07-164255-2, 2010
2	Kazda. A., Caves. R.E.	**"Airport Design and Operations",** 3rd Edition, Emerald Group Publishing Limited, ISBN: 978-1-78441-870-0, 2015
3	Ashford. N.J., Mumayiz. S.A., Wright. P.H.	**"Airport Engineering Planning, Design, and Development of 21st Century Airports",** 4th Edition, Wiley Publishing, ISBN:9780471527558, 2011

REFERENCE BOOKS:

1	AC 150/5320-6F - **Airport Pavement Design and Evaluation,** Federal Aviation Administration
2	AC 150/5340-1M - **Standards for Airport Markings,** Federal Aviation Administration
3	AC 150/5320-5D - Airport Drainage Design, Federal Aviation Administration
4	AC 150/5335-5C - **Standardized Method of Reporting Airport Pavement Strength** – PCN, Federal Aviation Administration
5	**Aerodrome Design Manual, Part-1: Runways,** International Civil Aviation Organization (ICAO)
6	**Aerodrome Design Manual, Part-2: Taxiways,** Aprons and Holding Bays, International Civil Aviation Organization (ICAO)
7	**Aerodrome, Volume 1: Aerodrome design and Operations,** International Civil Aviation Organization (ICAO)
8	ASTM D5340 (2012). **Standard Test Method for Airport Pavement Condition Index Surveys**
9	Airport Authority of India (AAI) Guidelines for airport planning and construction

Sub. Code	**N1CTME14**								
Course Title	**Transportation System Management**								
Course Type	**PEC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	3
Contact Hrs./Week	2	2	0	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	26	26	0	0	0	0	0	SEE Marks	50
Credits	2	1							
Total Contact Hrs.	**52**							Total Marks	100

Course Objective: The objective of this course is to introduce the student to concept of transportation management system (TSM) and its impact, actions involved in TSM, highway occupancy vehicle (HOV) treatments, demand and parking management and measures required to improve traffic operations.

Course Outcomes (COs): At the end of this course, the student will be able to	
CO1	Describe the concept of transportation system management and analyze its impact.
CO2	Describe the actions involved in traffic system management and perform impact analysis.
CO3	Describe the methods of promoting public transportation and highway occupancy vehicles treatment.
CO4	Describe various methods demand and parking management to meet the requirements.
CO5	Describe the various measures of improving traffic operations.

UNIT-I

Methodology & Data Collection: Methodological frame work, objectives and problems, conflicts resolution, strategic categories and action elements. Impact of TSM: Travel behaviour impact and response time, TSM actions combinations and interactions, impact assessment and evaluation, monitoring and surveillance **10 Hrs.**

UNIT-II

Area wide data collection methodology, corridor data collection methodology. **TSM Actions:** Study of following TSM actions with respect to problems addressed, conditions for applications, potential implementation problems, evaluation & impact analysis **10 Hrs.**

UNIT-III

Public transportation & HOV treatment: Toll discounts for car pools during peak periods, park and ride, car-pooling, exclusive lanes. Priority at ramp terminals, bus transfer stations, limited and skip-stop bus services, shared ride **10 Hrs.**

UNIT-IV

Demand Management: Staggered work hours, flexible work hours, high peak period tolls, shuttle services, circulation services, extended routes

Traffic Operations Improvement: On-street parking ban, freeway ramp control & closure, travel on shoulders, one-way streets, reversible lanes, Traffic calming, Right turn phase, right turn lanes, reroute turning traffic.

12 Hrs.

UNIT-V

Parking Management: Short term reserved parking, increased parking rates, time duration limits, expanded off-street parking, Non-Motorized Transport-pedestrian only streets, Dial a ride for elderly & handicapped. **10 Hrs.**

TEXT BOOKS:

1	Meyer Michael D and Eric J Miller,	**"Urban Transportation Planning – A Decision Oriented Approach",** Mc Graw Hill, New York, 2001.
2	Michael D. Meyer,	**"Transportation Planning Handbook",** Institute of Transportation Engineers, John Wiley & Sons, 2016.
3	Piyushimita (Vonu) Thakuriah and D. Glenn Geers,	**"Transportation and Information Trends in Technology and Policy",** Springer New York, 2013.

REFERENCE BOOKS:

1	D. Arlington	**"Transportation System Management in 1980: State of the Art and Future Directions",** Transportation Research Board, 1980.
2	Manheim M	**"Fundamentals of Transportation system approach",** MIT press, Cambridge, MA, 1985.
3	John G Schoon,	**"Transportation system and service policy",** Chapman and Hall, New York, 1996.

Sub. Code	N1PGRM								
Course Title	**Research Methodology and IPR**								
Course Type	**MCC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	3
Contact Hrs./Week	3	0	0	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	39	0	0	0	0	0	0	SEE Marks	50
Credits	3								
Total Contact Hrs.	**39**							Total Marks	100

Course Learning Objectives (CLOs)

- Identify the area of research and set the Objectives.
- Define the research problem and carryout literature
- Develop Research design and framework for experimentation
- Interpret Sampling design, Measurement and scaling techniques in RM
- Develop data collection and hypothesis testing procedure
- Interpret and write research and technical report.

Course Outcomes (COs): At the end of this course, the student will beable to	
CO1	Identify research categories and develop research plan.
CO2	Conduct and investigate the research problem and carryout literature review.
CO3	Investigate and Develop Research design and framework for experimentation.
CO4	Analyse and Develop Measurement and scaling techniques in their research & hypothesis testing procedure
CO5	Develop data collection and hypothesis testing procedure
CO6	Plan and develop systematically the research and technical report.

Unit - 1

Meaning, Objectives and Characteristics of research - Research methods Vs Methodology -Types of research - Descriptive Vs. Analytical, Applied Vs. Fundamental, Quantitative Vs. Qualitative, Conceptual Vs. Empirical - Research process - Criteria of good research -Developing a research plan.

8 Hrs.

Unit - 2

Defining the research problem - Selecting the problem - Necessity of defining the problem -Techniques involved in defining the problem - Importance of literature review in defining a problem- Survey of literature - Primary and secondary sources Identifying gap areas from literature review.

7 Hrs.

Unit - 3

Research design and methods – Research design – Basic Principles- Need of research design –– Features of good design – Important concepts relating to research design –- Developing a research plan - Exploration, Description, Diagnosis, and Experimentation - Determining experimental and sample designs.

8 Hrs.

Unit - 4

Sampling design - Steps in sampling design - Characteristics of a good sample design - Types of sample designs - Measurement and scaling techniques - Measurement in Research, Measurement Scales, Sources Of Error In Measurement, Tests Of Sound Measurement, Technique Of Developing Measurement Tools

Methods of data collection – Collection of primary data - Data collection instruments Testing of hypotheses - Basic concepts - Procedure for hypotheses testing flow diagram for hypotheses.

8 Hrs.

Unit - 5

Interpretation and report writing - Different steps in the preparation - Layout, structure and language of the report - Illustrations and tables - Types of report - Technical reports and thesis.

IPRs- Invention and Creativity- Intellectual Property-Importance and Protection of Intellectual Property Rights (IPRs) - A brief summary of Patents, Copyrights, Trademarks, Industrial Designs.

8 Hrs.

TEXT BOOKS:

Kothari, C.R	Research Methodology: Methods and Techniques. New Age International. 418p

REFERENCE BOOKS:

Garg, B.L., Karadia,R., Agarwal, F. and Agarwal, U.K.	2002, An introduction to Research Methodology, RBSA Publishers.
Subbarau NR	Handbook on Intellectual Property Law and Practice-S Viswanathan Printers and Publishing Private Limited.1998

Sub. Code	**N1CTML1**								
Course Title	**Advanced Pavement Materials Testing Lab**								
Course Type	**PCCL**								
	L	T	LA	PR	SE	PROJ	SS	Credits	2
Contact Hrs./Week	1	0	2	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	13	0	26	0	0	0	0	SEE Marks	50
Credits	1		1						
Total Contact Hrs.	**39**							Total Marks	100

Course Objective: The objective of this course is to provide hands-on training on the determination of strength and performance of subgrade soil and binder materials used in pavement construction and assess their performance when used in pavement construction. Also, the student is exposed to design of various types of bituminous and concrete mixes followed by their characterization, for its strength evaluation.

Course Outcomes (COs): At the end of this course, the student will be ableto	
CO1	Assess the strength of subgrade soil for pavement design.
CO2	Assess the performance of bitumen through its rheological characteristics.
CO3	Design various types of bituminous mixes and characterize them.
CO4	Design concrete mix for CC pavement and assess its strength.

1. Resilient modulus on subgrade soil. **06Hrs.**

2. Rheology of bitumen (VG 30grade). **06Hrs.**

3. Bituminous mix design by Marshall method. **18Hrs.**

- HMA mix design
- SMA mix design
- WMA mix design
- CMA Mix Design

4. Indirect tensile strength (ITS) test on bituminous mix **03Hrs.**

5. Concrete mix design **06Hrs.**

REFERENCE BOOKS:

1	S K Khanna, C E G Justo and A Veeraragavan, **"Highway Materials and Pavement Testing",** Nem Chand & Bros, 2013.
2	**"Asphalt Mix Design Methods – Manual Series 2",** 7th Edition, Asphalt Institute, 2015.
3	Relevant **IRC** code of practice
4	Relevant **IS** code of practice
5	Relevant **AASHTO** code of practice

SYLLABUS FOR

II semester

M. Tech.

(TRANSPORTATION ENGG. &

MANAGEMENT)

Sub. Code	**N2CTM01**								
Course Title	**Pavement Analysis and Design**								
Course Type	**IPCC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	4
Contact Hrs./Week	3	2	0	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	39	26	0	0	0	0	0	SEE Marks	50
Credits	3	1							
Total Contact Hrs.	**65**							Total Marks	100

Course Objective: The objective of this course is to introduce the student to the components of pavement structure, analysis of stresses in both flexible and rigid pavements, design of flexible and rigid pavements as per the relevant codes of practice.

Course Outcomes (COs): At the end of this course, the student will be ableto	
CO1	Describe the various components of pavements and their functions.
CO2	Analyze and evaluate the stresses in both flexible and rigid pavements
CO3	Design the flexible and rigid pavement structure as per the relevant codes of practice.
CO4	Design the pavement section using various alternate/sustainable materials and geosynthetics.

Unit-1

Pavements and pavement layers - types, functions, choice. Factors affecting design and performance of flexible and rigid pavements – Pavement design factors, loads – axle load distribution, ESWL, EWL, VDF due to varying loads and CSA, Subgrade support - CBR and plate bearing tests, Resilient Modulus, fatigue tests.

Concept of ESWL: ESWL for single and two-layer system in flexible pavement. Equivalent load factors. Applications to complex problems in pavement design using relevant software. **8 Hrs.**

Unit-2

Stresses and Deflection / strain in flexible pavements: Application of elastic theory, stresses, deflections / strains in single, two and three-layer system, multilayer theory.

Stresses in rigid pavements: General principle, stresses in rigid pavements, types of stresses, factors influencing the stresses, computation of stresses due to wheel loads and temperature variations, frictional stresses, stresses under worst conditions. **8 Hrs.**

Unit-3

Flexible pavement design: Empirical, semi empirical and theoretical design approaches, principle, advantages and applications. Design of flexible pavement as per IRC, AASHTO and Asphalt Institute methods using relevant software for specific highway projects for high volume roads and low volume roads. **8 Hrs.**

Unit-4

Design of rigid pavements: Types of joints in cement concrete pavements and their functioning, joint spacing; design of joint details for longitudinal joints, contraction joints and expansion joints. IRC method of design for high and low volume roads. Design of continuously reinforced concrete pavements, whitetopping. **7 Hrs.**

Unit-5

Designing with Geosynthetics: Property requirements and selection criteria of geosynthetics based on function, Design of reinforced unbound pavement layers, Design of asphalt reinforcement, Designing for separation, filtration and drainage applications.

Designing with alternate/sustainable materials: Requirements of various layers while designing with alternate/sustainable materials, Design of pavement sections with alternate/sustainable materials.

8 Hrs.

Lab Component:

- Analysis of flexible pavement – KENPAVE, IITPAVE **9 Hrs.**
- Analysis of rigid pavement – KENSLAB **5 Hrs.**
- Analysis of airfield pavement – FAARFIELD, COMFAA **12 Hrs.**

TEXTBOOKS:

1	Yoder E J and Witczak M W	"**Principles of Pavement Design"-** Wiley India Pvt Ltd., 2nd Edition, 2011.
2	Rajib B Mallick and Tahar EL-Korchi	**"Pavement Engineering Principles and Practice",** 3rd Edition, CRC Press, Taylor and Francis Group.
3	Huang	"**Pavement Analysis and Design**"- Pearson Education, 2nd Edition, 2008.
4	R. Srinivasa Kumar	**"**Pavement Design", Orient Blackswan Pvt. Ltd., New Delhi, 2013.

REFERENCE BOOKS:

1	Yang	"**Design of functional pavements"-** Mc Graw Hill Book Co., 1972
2	David Croney	Paul Croney, "**Design & Performance of Road Pavements",** Mc Graw Hill Book Co., 1997
3	W.Ronald Hudson, Ralph Haas and Zeniswki	"**Modern Pavement Management",** McGraw Hill and Co., 1st Edition, 1994
4	S.K. Khanna, C.E.G. Justo and A. Veeraragavan	**"Highway Engineering"**, Nem Chand and Bros. Roorkee, 10th Edition, 2014.
5	Relevant **IRC** codes.	
6	Relevant **AASHTO** guidelines.	

Sub. Code	N2CTM02								
Course Title	**Transportation Planning**								
Course Type	**PCC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	4
Contact Hrs./Week	3	2	0	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	39	26	0	0	0	0	0	SEE Marks	50
Credits	3	1							
Total Contact Hrs.	**65**							Total Marks:	100

Course Objective: The objective of this course is to introduce the student to the elements of urban transportation planning process, travel demand estimation, trip generation, trip distribution, mode choice, route assignment analysis and Land use Transportation Models.

Course Outcomes (COs): At the end of this course, the student will be ableto	
CO1	Explain planning process for an effective transportation system.
CO2	Explain the travel demand estimation, model the trip production and attraction
CO3	Evaluate the zonal trip generation and attraction for inter-zonal trip distribution.
CO4	Evaluate the modal split and transport system for assigning travel trips to various routes.
CO5	Describe the land use transportation models.

Unit-1

Urban Transportation Planning Process & Concepts: Role of Transportation and Changing Concerns of Society in Transportation Planning; Transportation Problems and Problem Domain; Objectives and Constraints; Flow Chart for Transportation Planning Process- Inventory, Model Building, Forecasting and Evaluation Stages, Planning in System Engineering Framework. **12 Hrs.**

Unit-2

Methods of Travel Demand Estimation: Travel Demand Forecasting methods - Introduction to Transportation Planning Practices; Definition of Study Area, Zoning.

Trip Generation Analysis: Trip Generation Models- Zonal Models, Category analysis, Household Models, Problems on Trip generation models.

12 Hrs.

Unit-3

Trip Distribution Analysis: Trip Distribution Models - Factors governing trip generation and attraction, Growth Factor Models, Gravity Models, Opportunity Models and their calibration; Application of the Gravity Model.

12 Hrs.

Unit-4

Mode Split and Route assignment analysis: Mode Split Analysis- Mode Choice Behaviour, Competing Modes, Mode Split Curves, Probabilistic Models and Two Stage Mode Split Analysis; Route Split Analysis- Elements of Transportation Networks, Diversion Curves, All-or-Nothing Assignment, Capacity Restrained Assignment, Multipath Assignment. **13 Hrs.**

Unit-5

Land use Transportation Models: Location models - Opportunity Models, Lowry based Land use Transportation Models – Allocation Function, Constraints, Travel Demand Estimation – Iterative Solutions, Matrix Formulation; Urban Forms & Urban Structures. **12 Hrs.**

TEXTBOOKS:

1	C.S. Papacostas and P.D. Prevendouros	**"Transportation Engineering and Planning",** Prentice-Hall of India Private Limited, New Delhi, (2001).
2	C.Jotin Khisty, B.Kent lall	**Transportation Engineering - An Introduction",** PHI Learning Pvt. Ltd., 3rd Edition, (2003)
3	Dr. Kadiyali, L.R.	"**Traffic Engineering and Transportation Planning",** Khanna Publication, 9th Edition, (1999).

REFERENCE BOOKS:

1	Hutchinson, B.G.	"**Principles of Urban Transport System Planning",** McGraw Hill Book Co., 1974
2	Bruton M J	**"Introduction to Transportation Planning",** UCLPress, 1992

Sub. Code	**N2CTM03**								
Course Title	**Pavement Management Systems**								
Elective/Core:	**PCC**								
	L	T	LA	PR	SE	PROJ	SS	Credits:	3
Contact Hrs./Week	2	2	0	0	0	0	0	CIE Marks:	50
Contact Hrs./Sem.	26	26	0	0	0	0	0	SEE Marks:	50
Credits	2	1							
Total Contact Hrs.	**52**							Total Marks:	100

Course Objective: The objective of this course is to introduce the student to the various types of pavement distresses, causes, enabling him/her to evaluate the present serviceability index, planning the maintenance program through repairs, rehabilitation and overlay, programming the prioritization by different models for flexible and rigid pavements and bridge structures. Also, the student will be able to understand various field tests for pavement evaluation.

Course Outcomes (COs): At the end of this course, the student will be able to	
CO1	Independently carry out investigation of the present serviceability index for pavements by considering different types of distresses and propose overlay design to enhance the structural stability of the pavement.
CO2	Communicate and write technical documents related to pavement management systems.
CO3	Showcase a degree of mastery in pavement management systems area.
CO4	Think and solve pavement related problems and arrive at feasible/optimal solutions
CO5	Apply modern engineering tools, equipment to evaluate and predict complex pavement engineering problems.
CO6	Understand engineering and management principles related to the road infrastructure.

Unit-1

Introduction to Pavement Management: Pavement Management Components Levels and functions; Definition-Components of Pavement Management Systems; network level versus project level PMS functions; Ideal PMS Network and Project levels of PMS; **8 Hrs.**

Unit–2

Highway Condition Surveys and Serviceability Evaluation: Pavement distress- types, identification, measurement and reporting of pavement distress data, Pavement condition index (PCI), functional condition deterioration models; Unevenness prediction models Roughness-roughness components, Equipment, Present serviceability index (PSI); Riding qualities by using Bump Integrator; International roughness index (IRI).

Structural Evaluation of Highway Pavements: Destructive structural analysis; Overlay design - Benkelman Beam deflection (BBD), Falling Weight Deflectometer equipment (FWD) - back calculation: rigid and flexible pavements; non-destructive testing. **16 Hrs.**

Unit–3

Highway Maintenance: Introduction, Preventive maintenance activities, Alternative maintenance treatments – Rehabilitation, Routine, Major **8 Hrs.**

Unit–4

Pavement Performance Prediction: Modelling techniques - structural condition deterioration models, mechanistic and empirical models, HDM and other models, comparison of different deterioration models. and other models, comparison case studies, Problems. **12 Hrs.**

Unit–5

Pavement Design Selection and Alternatives: Design objectives and constraints; basic structural response models; physical design inputs, Alternate pavement design strategies and economic evaluation, Expert systems approaches to identifying feasible alternatives – case study, life cycle costing (LCC) analysis. **8 Hrs.**

TEXT BOOKS:

1	W Ronald Hudson, Ralph Hass and Zeniswki	**"Modern Pavement Management",** Krieger Publishing Company, Original Edition, 1994
2	Yang H Huang	**"Pavement Analysis and Design",** Pearson Education; 2nd Edition, 2008
3	E.J.Yoder and M.W.Witczak	**"Pavement Design",** Wiley India Pvt Ltd., 2nd Edition 2011.

REFERENCE BOOKS:

1	David Croney and Paul Croney,	**"Design and Performance of Road Pavements",** 3rd Edition, McGraw-Hill Publishers, 1997.
2	W. Ronald Hudson, Ralph Haas and Waheed Uddin	**"Infrastructure Management: Integrating Design, Construction, Maintenance, Rehabilitation and Renovation",** McGraw-Hill, 1997

Sub. Code	**N2CTME21**								
Course Title	**Intelligent Transport Systems**								
Course Type	**PEC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	3
Contact Hrs./Week	2	2	0	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	26	26	0	0	0	0	0	SEE Marks	50
Credits	2	1							
Total Contact Hrs.	**52**							Total Marks	100

Course Objective: The objective of this course is to introduce the student to intelligent transport system, user services, advanced traveller information systems, sensor technologies in ITS, functional areas of ITS and applications of ITS.

Course Outcomes (COs): At the end of this course, the student will be ableto	
CO1	Describe the various ITS user services and traveller information services.
CO2	Describe the various sensor technologies and data requirements of ITS.
CO3	Describe the various functional areas and applications of ITS.
CO4	Describe the ITS models and evaluation methods and ITS planning.

UNIT-1

History of ITS, ITS – Need, Standards and policy, System architecture, ITS Developments - Worldwide and Indian scenario, Metropolitan and Rural ITS.

ITS User Services: Traffic Management centers - Types and functions, Travel and traffic management, Public transportation operations, Commercial vehicle operations

Advanced Traveller Information Systems: Pre trip and Enroute information, Data collection techniques, Route Guidance Systems, Infrastructure based systems and its applications, Variable message signs, Vehicle to Center and Vehicle to Road side communication. **12 Hrs.**

UNIT-2

Sensor Technologies and Data requirements of ITS: Importance of telecommunications in the ITS system, Information Management, Traffic Management Centres (TMC). Application of sensors to Traffic management; Traffic flow sensor technologies; Transponders and Communication systems; Data fusion at traffic management centres; Sensor plan and specification requirements; Elements of Vehicle Location and Route Navigation and Guidance concepts; ITS Data collection techniques – Detectors, Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), GIS, video data collection **10 Hrs.**

UNIT-3

ITS Functional Areas: Advanced Traffic Management systems (ATMS), Advanced Traveler Information systems (ATIS), Commercial Vehicle Operations (CVO), Advanced Vehicle Control systems (AVCS), Advanced Public Transportation systems (APTS), Advanced Rural Transportation systems (ARTS). ITS User Needs and Services – Travel and Traffic management, Public Transportation Management, Electronic Payment, Commercial Vehicle Operations, Emergency Management, Advanced Vehicle safety systems, Information Management. **10 Hrs.**

UNIT-4

ITS Architecture: Regional and Project ITS architecture; Concept of operations; ITS Models and Evaluation Methods; Planning and human factor issues for ITS, Case studies on deployment planning and system design and operation; ITS and safety, ITS and security, ITS as a technology deployment program, research, development and business models, ITS planning

10 Hrs.

UNIT-5

ITS Applications: Traffic and incident management systems; ITS and sustainable mobility, travel demand management, electronic toll collection, ITS and road-pricing.; Transportation network operations; commercial vehicle operations and intermodal freight; public transportation applications; ITS and regional strategic transportation planning, including regional architectures: ITS and changing transportation institutions 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 **10 Hrs.**

TEXTBOOKS:

1	Mashrur A. Chowdhury, Adel Wadid Sadek	**"Fundamentals of intelligent transportation systems planning",** Artech House, 2003
2	Lawrence A. Klein	**"Sensor technologies and Data requirements of ITS",** Artech House, 2001
3	Sussman, J. M	**"Perspective on ITS",** Artech House Publishers, 2005
4	Kan Paul Chen, John Miles	**"PIARC ITS Hand Book: Recommendations for World Road Association",** 2nd Edition, 2004.

REFERENCE BOOKS:

1	Samuel Morgan	**"Intelligent Transportation Systems: Technologies and Applications",** Clanrye International, 2015
2	Marco Picone	**"Advanced Technologies for Intelligent Transportation Systems",** New York, NY, Springer, 2014
3	Sussman, Joseph	**"Perspectives on Intelligent Transportation Systems (ITS)",** New York, NY, Springer, 2010
4	**"National ITS Architecture Documentation",** US Department of Transportation, 2007	

Sub. Code	**N2CTME22**								
Course Title	**Urban Public Transport**								
Course Type	**PEC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	3
Contact Hrs./Week	2	2	0	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	26	26	0	0	0	0	0	SEE Marks	50
Credits	2	1	0						
Total Contact Hrs.	**52**							Total Marks	100

Course Objective: The objective of this course is to introduce the student to different modes of urban transport, designing transport facilities for pedestrians, use of different transportation modes, feasibility study on different alternative modes including rapid transit, transportation system management and transit system evaluation, quantification of performance, planning and management of city traffic and perspectives of future transportation.

Course Outcomes (COs): At the end of this course, the student will be ableto	
CO1	Describe the need for different modes of transportation and para transit and ride sharing, designing for pedestrians, trends in transit rider ship.
CO2	Compare costs and carryout comparative analysis of operational and technological characteristics of different modes of rapid transit.
CO3	Describe the limitations of conventional transportation system and perspectives of future transport.
CO4	Describe planning of transportation system including service, financing, management and marketing.
CO5	Describe quantitative performance attributes of transit system.

Unit-1

System and Technologies: Urban passenger transportation modes, transit classifications and definitions, theory of urban passenger transport modes, rail transit, bus transit, Para transit and ride sharing, designing for pedestrians, trends in transit rider ship and use of different modes. **10 Hrs.**

Unit-2

Comparative Evaluation of Alternatives: Comparing costs, comparative analysis, operational and technological characteristics of different rapid transit modes,evaluating rapid transit. **10 Hrs.**

Unit-3

Urban traffic: Classification of transportation systems, conventional transportation systems, unconventional transportation systems, prototypes and tomorrow's solutions, Analysis and interpretation of information on transportation systems, perspectives of future transportation. **12 Hrs.**

Unit-4

Planning: Transportation system management, system and service planning, financing public transportation, management of public transportation, public transportation marketing. **10 Hrs.**

Unit-5

Transit System Evaluation: Definition of quantitative performance attributes, transit lane capacity, way capacity, station capacity, theoretical and practical capacities of major transit modes, quantification of performance. **10 Hrs.**

TEXTBOOKS:

1	Vukan R. Vuchic	**"Urban Public Transportation Systems and Technology",** Prentice Hall Inc., New Jersey, 2007
2	George E. Gray and Lester A. Hoel	**"Public Transportation",** Prentice Hall, New Jersey, 2nd Edition, 1993

REFERENCE BOOKS:

1	John W. Dickey	**"Metropolitan Transportation Planning**, TMH, New Delhi, 2nd Edition, 1983
2	Horst R. Weigelt, Rainer E. Gotz, Helmut H. Weiss	**"City traffic – A Systems Digest",** Van Nastrand Reinhold company, New York, 1977

Sub. Code	**N2CTME23**								
Course Title	**Sustainable Transportation**								
Course Type	**PEC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	3
Contact Hrs./Week	2	2	0	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	26	26	0	0	0	0	0	SEE Marks	50
Credits	2	1	0						
Total Contact Hrs.	**52**							Total Marks	100

Course Objective: The objective of this course is to introduce the student to problems of sustainability, planning for sustainability, related policies, technology, and appropriate mitigation actions with respect to transportation.

Course Outcomes (COs): At the end of this course, the student will be ableto	
CO1	Describe the problem of sustainability in transport.
CO2	Describe the pricing and taxation of transportation and plan sustainability for transportation.
CO3	Describe the sustainability related policies for transportation.
CO4	Describe the various technology associated with sustainable transportation.
CO5	Describe necessary mitigation actions required for enabling sustainable transportation.

Unit-1

Problem of Sustainability in Transport: Energy use in transport sector; Transport and climate change; Greenhouse gas emissions, Urban air quality, Congestion and sustainability. **10 Hrs.**

Unit-2

Pricing Transportation: Full cost of transportation, pricing and taxation.

Planning for Sustainability: Urban form, Indicator based planning, Land use transportation integration. **10 Hrs.**

Unit-3

Sustainable Policies: Continuum of Policies, speed and speed limit policies, national policies, sustainable travel demand management; Public awareness of policies. **10 Hrs.**

Unit-4

Sustainable Technology: Telecommuting, Information and Communication technologies, E-commerce, Alternative Cleaner Fuels, Fuel cells and other Vehicular technologies, Intelligent Transport System. **12 Hrs.**

Unit-5

Urban Transport and Sustainability – Multimodal transportation (MMT) environment, level of service, design of multimodal transfer facilities, park and ride facility planning. **10 Hrs.**

TEXTBOOKS:

1	Preston L. Schiller, Eric C. Brunn and Jeffrey R. Kenworthy.	**"An Introduction to Sustainable Transportation: Policy",** Planning and Implementation, 2010.
2	Cervero, R	**"Accessible Cities and Regions: A Framework for Sustainable Transport and Urbanism in the 21st Century",** Center for Future Urban Transport, Institute of Transportation Studies, University of California, Berkeley, 2005

REFERENCE BOOKS:

1	Black W R	**"Sustainable Transport: Definitions and Responses", i**n Transportation Research Board, Integrating Sustainability into the Transportation Planning Process, Conference Proceedings 37. Washington, D.C., National Research Council, 2005
2	Black W R	**"Sustainable Transport: Problems and Solutions",** Gulford Press, New York, 2010.
3	Mehrdad Ehsani, Fei-Yue Wang and Gary L. Brosch (Eds.), "**Transportation technologies for sustainability",** 2013.	
4	Rodney Tolley (Editor), "**Sustainable Transport: Planning for walking and cycling in urban environments",** CRC Press, 2003.	

Sub. Code	**N2CTME24**								
Course Title	**Advanced Traffic Engineering**								
Course Type	**PEC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	3
Contact Hrs./Week	2	2	0	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	26	26	0	0	0	0	0	SEE Marks	50
Credits	2	1	0						
Total Contact Hrs.	**52**							Total Marks	100

Course Objective: The objective of this course is to introduce the student to traffic stream characteristics and models, toll operations, queuing theory, pedestrian related studies and simulation models.

Course Outcomes (COs): At the end of this course, the student will be ableto	
CO1	Describe the traffic stream characteristics.
CO2	Apply traffic stream models to analyze the traffic conditions.
CO3	Apply queuing theory to facilities such as toll booths and parking garages to maximize the service.
CO4	Analyze the pedestrian problems and its influence on the traffic flow.
CO5	Describe the basic concepts of traffic simulation modelling.

UNIT-1

Traffic Stream Description: Traffic Stream Characteristics; Microscopic and Macroscopic Study of Traffic Stream Characteristics - Flow, Speed and Concentration; Gaps and Lags, Gap acceptance in a traffic stream; Time-space diagram; Measurement of Traffic Stream Characteristics; Distributions for describing Vehicle Arrivals, Headways, Speeds; Fitting of Distributions; Goodness of Fit Tests. **10 Hrs.**

UNIT-2

Traffic Stream Models: Fundamental Equation of Traffic Flow, Speed-Flow-Concentration Relationships, Hydrodynamic and Kinematic Modeling, Bottleneck situations and shockwaves; Shock Wave Theory – Use of Flow Density diagram in Shockwave analysis; Numerical examples on application of shockwave theory; Car-Following Theory, Linear Car-Following Model and its significance. **12 Hrs.**

UNIT-3

Queuing Theory: Fundamentals of Queuing Theory, Input parameters, Queue discipline describing the vehicles arrival at a service facility, Queuing system performance measures, Queuing Patterns, Queuing Models - Analysis of M/M/1 model; Application of M/M/1 model for parking Garages and Toll Plazas, Numerical Examples; Analysis of D/D/1 system for delay characteristics; Computation of delays and queue dissipation Time, Numerical Examples; Application of M/M/N model, Numerical Examples.

12 Hrs.

UNIT-IV

Pedestrian Studies: Pedestrian problems, Space requirements, Walking speed, Startup time and capacity; Pedestrian flow characteristics; Pedestrian Level of Service; Pedestrian facilities; Critical pedestrian gap; Pedestrian gap acceptance; Concept of Blocks and Anti-blocks, Warrants for Pedestrian Crossing Facilities. **10 Hrs.**

UNIT-V

Simulation Models: Philosophy of Simulation Modelling, Need for Simulation, Applications, Classifications, Methodology of System Simulation, Simulation Languages / System Packages, Formulation of Simulation Model for a Traffic Engineering problem, Model Calibration, Determination of Errors, Generation of Random Numbers, Generation of Inputs – Vehicle Arrivals, Vehicle Characteristics, Road Geometrics, Verification and Validation Techniques, Numerical Examples. **8 Hrs.**

Self-Study: Field visits to understand the traffic stream characteristics in practical scenario, to analyze the application of queuing theory in toll booths, to evaluate pedestrian behavior on roads.

TEXT BOOKS:

1	F.L. Mannering, and S.S. Washburn	**"Principles of Highway Engineering and Traffic Analysis",** John Wiley Publishers, 7th edition, 2019.
2	A.D. May	**"Traffic Flow Fundamentals",** Prentice Hall incorporated, US, 1990.
3	C.Jotin Khisty, B.Kentlall	**"Transportation Engineering: An Introduction",** PHI India, 3rd Edition, (2002)

REFERENCE BOOKS:

1	Roger.P.Roess, Elena.S.Prassas and William.R.McShane	**"Traffic Engineering", 5th edition Pearson, US 2019.**
2	C.S. Papacostas	**"Fundamentals of Transportation Engineering",** Prentice-Hall of India Private Limited, New Delhi, 3rd edition 2002
3	Dr. L.R. Kadiyali	**"Traffic Engineering and Transport Planning",** Khanna Publishers, 9th Edition, 1999
4	**Daniel.L.Gerlough** and Matthew.J.Huber	**"Traffic Flow Theory: A Monograph",** TRB Special Report 165, 1975 (Revised and expanded in 2017)

Sub. Code	**N2CTME31**								
Course Title	**Design of Reinforced Earth Structures**								
Elective/Core	**PEC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	3
Contact Hrs./Week	2	2	0	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	26	26	0	0	0	0	0	SEE Marks	50
Credits	2	1							
Total Contact Hrs.	**52**							Total Marks	100

Course Objective: The objective of this course is to introduce the student to basic concepts of reinforced earth structures, designing with geosynthetics, reinforced wall design, analysis and design of soil nailing, stability analysis and design of embankments on soft soil with and without reinforcement, use of geosynthetics for filtration and drainage and application of geosynthetics in road pavements. .

Course Outcomes (COs): At the end of this course, the student will be ableto	
CO1	Describe the strength characteristics and strength development in reinforced soil along with the failure modes, theoretical models and stress – strain characteristics.
CO2	Describe the function and mechanisms of geosynthetics test methods for the determination of geotextile properties to formulate design criteria for filtration and drainage applications with due consideration to serviceability and durability criteria.
CO3	Design geosynthetic reinforced roads by Giroud – Noiray approach.
CO4	Analyze the internal stability failure mechanism of a reinforced soil wall system.
CO5	Analyze and design reinforced soil beds for improved bearing capacity.
CO6	Design and analyze the soil nailed slopes and describe the construction practice.

Unit-1

Reinforced Earth Structures

Introduction, basic mechanism of Reinforced earth, Basic components of reinforced soil, Soil or Fill matrix, Reinforcement (Strips, Grids, Sheet Reinforcement), Facing Elements - Metal facing, Concrete Panel facing, Strength characteristics of Reinforced soil - Basic concept of strength development: rupture and sliding failure, Theoretical models: Sigma and Tau models, Stress strain behavior of reinforced sand. **10 Hrs.**

Unit-2

Designing with Geosynthetics

Introduction, materials, Geotextiles Functions and Mechanisms - Separation, Reinforcement, Filtration, Drainage, Contaminant. Geotextiles Properties and Test Methods - Physical properties, Mechanical properties, Hydraulic properties.

Use of Geosynthetics for filtration and drainage

Introduction, Background, Applications, Conventional Granular Filter Design criteria, Geotextile Filter Requirements, Boundary conditions, Drain and filter properties, Design criteria, Soil retention criteria, Geotextile permeability criteria, Anti-clogging criteria, Survivability criteria, Durability criteria.

10 Hrs.

Unit-3

Use of Geosynthetics in Roads

Introduction, Geosynthetics in Roadways, Applications, Temporary and permanent roads, Benefits, Role of sub grade conditions, Design, The Giroud and Noiray Approach, Geotextile Survivability, Application in Paved Roads.

Reinforced Soil Wall

General, Stability analysis - External stability, Internal stability. Effect of vertical and horizontal line loads-External stability, Internal stability, Drainage requirements. **10 Hrs.**

Unit-4

Embankments on soft soil

Introduction, Analysis- Internal stability, Overall stability, Stability in the foundation. Influence of Reinforcement Extensibility, Relationships for design, Deformation in foundation, Settlement analysis, Overall stability with respect to bearing, Safety factors.

Foundations on Reinforced Soil Beds

Introduction, Failure modes, Analysis and design of reinforced soil beds

10 Hrs.

Unit-5

Soil Nailing

General, Applications, Advantages Limitations of the system, Comparison of soil nailing with reinforced soil, Method of soil nailing, Construction sequence, Components of system, Analysis and Design-Assumptions, Geometry of Rupture surface, Forces acting on the wedge, Parametric study, Design, Case Histories.

Design of Reinforced Soil slopes

Introduction, General approach, Jewell's Method, Choice of design values for parameters and use of charts, Soil properties, Properties of reinforcement materials, Interaction parameters, Steps for simplified design, Design examples. **12 Hrs.**

TEXTBOOKS:

1	Swami Saran	**"Reinforced Soil and its Engineering Applications",** I.K. International Publishing House Pvt. Ltd., 3rd Revised Edition, 2017.
2	G L Sivakumar Babu	**"An Introduction to Soil Reinforcement and Geosynthetics",** Universities Press, 1st Edition, 2005

REFERENCE BOOKS:

1	R M Koerner	**"Designing with Geosynthetics",** Prentice Hall, 6th Edition, Vol. 2, 2012
2	Sanjay Kumar Shukla	"**An Introduction to Geosynthetic Engineering**", CRC Press; 1st edition 2016
3	Braja M. Das,	"**Principles of Geotechnical Engineering**", PWS Publishing Company, Boston, 7th Edition, 2010
4	Joseph E. Bowles	**"Foundation Analysis & Design",** The McGraw-Hill Companies Inc., New York, 3rd Edition, 1977
5	Relevant **IRC** publications	

Sub. Code	**N2CTME32**								
Course Title	**Transportation Economics**								
Course Type	**PEC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	3
Contact Hrs./Week	2	2	0	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	26	26	0	0	0	0	0	SEE Marks	50
Credits	2	1							
Total Contact Hrs.	**52**							Total Marks	100

Course Objective: The objective of this course is to introduce the student to the basic concepts of economics, evaluation of the benefits associated with improvements and their costs and enable them to perform economic analysis of road projects.

Course Outcomes (COs): At the end of this course, the student will be ableto	
CO1	Describe the fundamental concepts of economics in connection with transportation projects.
CO2	Evaluate various transportation costs and benefits associated with improvements.
CO3	Apply economic theory for different transportation costs.
CO4	Analyze costs of various aspects of transportation such as accidents, public bus transit.
CO5	Apply economic theory to traffic assignment problems.

Unit-1

Introduction: Significance of transport, Demand and supply of transport, Elasticity of demand and supply concepts and principles of highway engineering economy. Costs and Benefits Identification and measurements of transportation costs and benefits, Capital cost, Inflation cost Interest during construction, Maintenance cost, Road user costs, Fixed and operating costs. **10 Hrs.**

Unit-2

Benefits due to transport improvements: Direct benefits- Reduced vehicle operation cost, value of travel time savings, value of increased comfort and convenience, cost of accident reduction, reduction in maintenance cost. Negative impacts due to increased noise and air pollution, Indirect benefits: increased land value, increased development and demand. **10 Hrs.**

Unit-3

Transportation costs: Fixed and variable cost, cost of improvement, maintenance cost and other related cost, cost estimation methods, accounting for inflation, theory of transport supply and road planning. **10 Hrs.**

Unit-4

Accident cost, Methodology for monetary evaluation of passenger's travel time, Value of increased comfort and convenience, Congestion cost and pricing, Consumer's surplus and social surplus criteria, Fare policy for bus transit. **10 Hrs.**

Unit-5

Economic analysis: The generation and screening of project ideas. Different methods of economic analysis – capital budgeting. Case studies.

Application of Economic Theory in Traffic Assignment Problem: User optimal assignment and system optimal assignment. Economic analysis of projects – financing of road projects, methods of financing – PPP, toll collection. Economic variability of Build-Operate-Transfer schemes – Risk analysis. **12 Hrs.**

TEXT BOOKS:

1	Robley Winfrey	**"Economic Analysis for Highways",** International Textbook Company, 1969
2	Emile Quinet, Roger Vickerman.,	**"Principles of Transport Economics",** Edward Elgar Publishing, 2004
3	James L.Riggs, David D.Bedworth, and Sabah U. Randhawa.,	**"Engineering Economics",** Tata McGraw Hill, Delhi,2009

REFERENCE BOOKS:

1	Sasmita Mishra	**"Engineering Economics and Costing",** PHI, New Delhi.
2	Sarkar P K., Maitri V	**"Economics in Highway and Transportation Planning",** Standard Publisher, New Delhi, 2010.
3	David A. Hensher, Ann M. Brewer	**"Transport: An Economics and Management Perspective",** Oxford University Press, 2001.
4	Emile Quinet, Roger Vickerman,	**"Principles Of Transport Economics",** Edward Elgar Publishing, 2005.
5	Ian G. Heggie,	**"Transportation Engineering Economics",** McGraw Hill, 1972.
6	**"Transportation systems Management and Operations – Benefit-Cost Analysis Compendium," US Department of Transportation – Federal Highway Administration, 2020.**	
7	Relevant FHA, US Department of Transportation Publications on Economic Development.	

Sub. Code	**N2CTME33**								
Course Title	**Environmental Impact Assessment of Transportation Projects**								
Course Type	**PEC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	3
Contact Hrs./Week	2	2	0	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	26	26	0	0	0	0	0	SEE Marks	50
Credits	2	1							
Total Contact Hrs.	**52**							Total Marks	100

Course Objective: The objective of this course is to introduce the student to the concept and development of EIA, methodologies, application of EIA in transportation, impact of transportation on water and air environment, impact of noise and socio-economic impacts in EIA studies.

Course Outcomes (COs): At the end of this course, the student will be ableto	
CO1	Describe the concept, development and methodologies of environmental impact assessment.
CO2	Describe the application of environmental impact assessment in transportation.
CO3	Assess the impact of transportation projects on water and air environment including the impact of noise.
CO4	Describe the socio-economic impacts of environmental impact assessment studies.

Unit-1

Introduction to Environmental Impact Assessment (EIA): Objectives and Needs- development of EIA - National Environmental Protection Act 1986 – Key features. Rapid EIA – Comprehensive EIA – Strategic EIA- procedure for EIA in India.

EIA Methodologies: Formulation of EIA team –inter disciplinary approach -Screening – Scoping - checklist, matrix and network methodologies - Identification of Impacts – Collection and documentation of baseline data –Need for Prediction and Mitigation Measures **10 Hrs.**

Unit-2

Application of EIA in Transportation Projects: Public participation in Environmental decision making - techniques for conflict management and dispute resolution in transportation projects. Role of GIS and RS in environmental impact assessment of transportation projects. **10 Hrs.**

Unit-3

Assessment and prediction of Impacts on Water Environment: Basic water quality, sources and effects of water pollution, assessment and prediction of impacts, Streeter Phelps equation and its application in EIA studies. Mathematical modelling for prediction of water pollution on account of transportation projects, mitigation measures, legislations.

10 Hrs.

Unit-4

Assessment and prediction of Impacts on Air Environment: Air quality, sources and effects of air pollution, assessment and prediction of impacts, Gaussian distribution for air pollution for point and line sources, mitigation measures, legislations.

Assessment of Impacts of Noise: Basic information, sources and effects of noise pollution, control measures, legislations

12 Hrs.

Unit-5

Socio-economic impacts in EIA studies: Ecological impacts – Ecological foot-prints– Environmental Indices. Introduction to Environmental Management Systems - Cost Benefit Analysis - Environmental Audit - Life cycle Assessment – Environmental Risk assessment – Case studies from India **10 Hrs.**

TEXTBOOKS:

1	John. G Rau and David C Wooten	**"Environmental Impact Analysis Hand Book",** McGraw Hill, 1980
2	Canter L W	**"Environmental Impact Assessment",** McGraw Hill New York 1996

REFERENCE BOOKS:

1	Petts.J	**"Handbook of environmental Impact Assessment, M Land",** Blackwell Science, London, 1999
2	Suresh K. Dhameja	**"Environmental Engineering and Management",** S.K. Kataria & Sons, 2010
3	Davis, M.L., and Cornell, D A	**"Introduction to Environmental Engineering",** Mc Graw Hill International Editions, 1998
4	Betty Marriott	**"Environmental Impact Assessment: A Practical Guide",** McGraw Hill Professional, 1997.

Sub. Code	**N2CTME34**								
Course Title	**Ground Improvement Techniques**								
Course Type	**PEC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	3
Contact Hrs./Week	2	2	0	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	26	26	0	0	0	0	0	SEE Marks	50
Credits	2	1							
Total Contact Hrs.	**52**							Total Marks	100

Course Objective: The objective of this course is to introduce the student to the behavior of soft/weak/compressible soil deposits, necessity of ground improvement and various conventional and latest stabilization techniques.

Course Outcomes (COs): At the end of this course, the student will be able to	
CO1	Describe the behavior of weak/soft/collapsible soils and highlight the importance of ground improvement.
CO2	Describe the various conventional and latest ground improvement techniques.
CO3	Describe the soil – reinforcement interaction, Design and analyze the reinforced soil slopes.
CO4	Describe the various geosynthetic materials, their functions, design and analyze the improved deposits for bearing capacity and settlement.

Unit-1

Introduction: Engineering properties of soft, weak and compressible deposits, problems associated with weak deposit, Requirements of ground improvements, introduction to engineering ground modification, need and objectives. **10 Hrs.**

Unit-2

Soil Stabilization: Science of soil stabilization – Mechanical modification, Hydraulic modification, Dewatering systems, Chemical modification, Modification by admixtures like lime, cement, bitumen, etc., Grouting, Deep jet mixing methods **10 Hrs.**

Unit-3

Recent Ground Improvement Techniques: Stabilization using industrial waste, modification by inclusion and confinement, soil nailing, stone column, compaction piles, dynamic compaction, prefabricated vertical drains, preloading, electro – osmosis, soil freezing vacuum consolidation, deep explosion, dry powdered polymers, enzymes **12 Hrs.**

Unit-4

Soil reinforcement: Historical background, RCC – Vidalean concept of reinforced earth, mechanisms, types of reinforcements, Soil – Reinforcement interaction studies – Internal & External stability criteria, Design principles of steep reinforced soil slops, embankments on soft soils. **10 Hrs.**

Unit-5

Geo-Synthetics: Geo Synthetic materials, functions, property characterization, testing methods for Geo– synthetics, recent research and developments, control of improvement, field instrumentation, design and analysis for bearing capacity and settlement of improved deposits. **10 Hrs.**

TEXTBOOKS:

1	Hausmann M R	**"Engineering Principles of Ground Modification,"** McGraw – Hill International Editions, 1990
2	Purushotham Raj,	**"Ground Improvement Techniques",** Laxmi Publications, New Delhi

REFERENCE BOOKS:

1	Jones C. J. F. P,	**"Earth Reinforcement and Soil Structures",** Butterworths, London.
2	Sharma S K	**"Principles, Practice and Design of Highway Engineering",** S.Chand & Co. New Delhi,1985
3	Relevant **IS and IRC** codes	

Sub. Code	**N2OE01**								
Course Title	**Fuzzy Logic and Engineering Applications**								
Course Type	**OEC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	3
Contact Hrs./Week	3	0	0	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	39	0	0	0	0	0	0	SEE Marks	50
Credits	3								
Total Contact Hrs.	**39**							Total Marks	100

Course objectives: The objective of this course is,

- To understand uncertainty of non-statistical kind.
- To learn the ways to develop membership functions
- To understand defuzzification methods.
- To learn extension principle and to perform fuzzy arithmetic and fuzzy calculus.

Course Outcomes (COs): At the end of this course, the student will be able to	
CO1	Develop membership functions and perform various fuzzy setoperations.
CO2	Decide on the nature of fuzzy membership functions and develop algorithms for the same. Apply various methods of defuzzification and to determine scalar output.
CO3	Apply methods such as intuition, inference, and rank ordering to develop membership function for the given engineering problem having uncertain variables.
CO4	Apply principles of fuzzy synthetic evaluation, fuzzy ordering and preference and be able to take decisions in uncertain environments.
CO5	Develop fuzzy membership function in the consequent space using discrete as well as continuous antecedent variables.

Unit-1

Introduction to fuzzy notions, uncertainty, uncertainty in information. Utility of fuzzy systems and limitations. Fuzzy sets and membership functions. Examples of engineering interest. Classical sets and fuzzy sets. Fuzzy set operations and properties of fuzzy sets. **7 Hrs.**

Unit-2

Membership functions, properties, various forms and their algorithms, fuzzyfication. Defuzzification- various methods, applications related to engineering **9 Hrs.**

Unit-3

Developing membership functions, method of inference, intuition and rank ordering. Example problems of engineering interest. **8 Hrs.**

Unit-4

Decision making with uncertain or fuzzy information. Fuzzy synthetic evaluation, fuzzy ordering, preference and consensus. **8 Hrs.**

Unit-5

Fuzzy extension principle, fuzzy arithmetic with discrete variables and continuous Variables, interval analysis, vertex method and other methods.

Assignment component: Students have to submit a small project report consisting of an application of fuzzy logic concepts using MatLab in their domain of study(7marks). **8 Hrs.**

TEXTBOOKS:

1.	Timoty **J** Ross, Fuzzy logic with Engineering applications, 4th edition, Willy publications, ISBN: 978-1-119-23586-6

REFERENCE BOOKS:

1.	George Bojadzive, Maria Bojadzive, Fuzzy sets, fuzzy logic and Applicaions,World Scientific Publications, 1995.
2.	Massavo Mukaidono, Fuzzy Logic for Beginners, World Scintific Publications, 2001.

Sub. Code	**N2OE02**								
Course Title	**Fundamentals of Data Analytics**								
Course Type	**OEC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	3
Contact Hrs./Week	3	0	0	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	39	0	0	0	0	0	0	SEE Marks	50
Credits	3								
Total Contact Hrs.	**39**							Total Marks	100

Course objectives: The objectives of this course are to,

- Get an overall view of data analysis based on CRISP-DM process model.
- Study data quality assessment and visualization techniques for data involving two attributes and for higher dimensional data.
- Understand principles of modeling by going through various data modeling techniques.
- Get a detailed account of data preparation phase.
- Study statistical concepts related to data analysis.
- Enable students to independently perform data analytic procedures on given data pertaining to civil engineering using Excel.

Unit-1

Data and knowledge, criteria to assess the knowledge, descriptive statistics of the data, inferential statistics, exploratory data analysis, knowledge discovery in data bases, data analysis processes, SEMMA, CRISP-DM, methods, tasks and tools.

7 Hrs.

Unit-2

Attribute understanding, kinds of attributes (nominal, interval, ratio types). Characteristics of one-dimensional data, location measures, dispersion measures, and shape measures. Characteristic measures of multidimensional data, data quality, visual analytics of one-dimensional data, density plots, box plots, scatter plots. Correlation and covariance. Methods for multidimensional data (just briefing). Analysis of data pertaining to specialization. **8 Hrs.**

Unit-3

The four steps of modelling, model classes, black-box models, fitting criteria and score functions, error functions for classification problems, measure of interestingness, closed form algorithm for model fitting. Types of errors. Model validation (briefing on methods). Modelling on the data specific to specialization.

8 Hrs.

Unit-4

Selection of data, feature selection, selecting top ranked subset of data, cross product, wrapper approach, and correlation-based filter. Cleaning data, improving data quality, dealing with missing values, construct data, providing operability, assuring impartiality and maximize efficiency. Complex data types. Implementation of methods on data specific to specialization. **8Hrs**.

Unit-5

Clustering – methods. Hierarchical clustering. Dissimilarity measures, Minkowisci, Euclidian, Manhattan, Chebyshev, and cosine. Deviation measures. Association rules. Brief introduction to self-organizing maps. Implementation of methods on data specific to branch of specialization.

8 Hrs.

TEXTBOOKS:

1.	Michel R. Berthold, Christian Borgelt, Frank Hoopner, Guide to Intelligent Data Analysis, Springer- Verlag Publications, ISBN 978-1-84882-259-7, DOI 10.1007/978-1-84882-260-3, London, 2010

REFERENCE BOOKS:

1.	Charles M.Zudd, Garry H.Mcchelland, Carry S.Ryan, Data Analysis: A Model Comparison Approach, Routledge Publication, NY, 2009.
2.	Allan Agresty, An Introduction to Categorical Data Analysis, 2nd Edition, Wiley Publication

Sub. Code	**N2OE03**								
Course Title	**Introduction to AI & ML**								
Course Type	**OEC**								
	L	T	LA	PR	SE	PROJ	SS	Credits	3
Contact Hrs./Week	3	0	0	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	39	0	0	0	0	0	0	SEE Marks	50
Credits	3								
Total Contact Hrs.	**39**							Total Marks	100

Course objectives: The primary objective of this course is to introduce the basic principles, techniques, and applications of Artificial Intelligence specifically to students of non-IT branches. Emphasis will be placed on the teaching of these fundamentals, not on providing a mastery of specific software tools or programming environments. Specific objectives are to:

- Gain a historical perspective of AI and its foundations.
- Become familiar with basic principles of AI toward problem solving, inference, perception, knowledge representation, and learning.
- Investigate applications of AI techniques in artificial neural networks and other machine learning models.
- Explore the current scope, potential, limitations, and implications of intelligent systems.

Course Outcomes (COs): At the end of this course, the student will be ableto:	
CO1	Demonstrate fundamental understanding of the history of artificial intelligence (AI) and its foundations.
CO2	Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation, and learning.
CO3	Demonstrate awareness and a fundamental understanding of various applications of AI techniques in intelligent agents, expert systems, artificial neural networks and other machine learning models.
CO4	Identify problems exclusive to a particular engineering discipline that can be addressed under the ambit of AI.
CO5	Demonstrate an ability to share in discussions of AI, its current scope and limitations, and societal implications.

Unit-1

Introduction, a brief history of AI, strong methods and weak methods, uses and limitations, AI in future, knowledge representation, the need for good representation, semantic nets, inheritance and frames. General applications of AI in various engineering domains. **7 Hrs.**

Unit-2

Search methodologies, problem solving as search, data driven /goal driven search, depth first search, breadth first search, problem solving as search,

properties of such methods, why humans use depth first search, illustrative examples (traversing a Maze, searching for gift), informed and uninformed methods of searching. Illustrative real-world problems of engineering interest.

8 Hrs.

Unit-3

Introduction to Machine Learning, Concept learning, general-to-specific ordering, version spaces, inductive bias, general to specific ordering, version spaces, supervised learning, unsupervised learning, reinforcement learning. Illustrative real-world examples of machine learning of engineering interest.

Unit-4

Artificial Neural networks, introduction, neurons, perceptrons, the capabilities of a single perceptron, multilayer neural networks, capabilities of multilayer neural networks, back propagation, unsupervised learning networks, kohonen maps. Illustrative real-world examples on applications of neural networks in various engineering domains. **8 Hrs**.

Unit-5

Learning under uncertainty and ambiguity, fuzzy logic, linguistic variables, fuzzy sets, membership functions, fuzzy set operations, fuzzy expert systems, fuzzification, defuzzification, fuzzy rules, fuzzy inferences. Illustrative examples of engineering applications of fuzzy logic. **8 Hrs.**

TEXTBOOKS:

1	Stuart Russell and Peter Norvig, Artificial Intelligence a Modren Approach, Third edition, Pearson Education, III edition, 2010.
2	Ben Coppin, Artificial Intelligence Illuminated, Narosa Publications, 2014.

REFERENCE BOOKS:

1	***David. L. Poole, Alan K. Mackworth***, Artificial Intelligence – Foundations of Computational Agents, II edition, Cambridge University Press, 2010.
2	***Kevin Warwick***, Artificial Intelligence-The Basics, Routledge Publications, USA,2012

Sub. Code	**N2CTML1**								
Course Title	**Design Studio**								
Course Type	**PCCL**								
	L	T	LA	PR	SE	PROJ	SS	Credits	2
Contact Hrs./Week	1	0	2	0	0	0	0	CIE Marks	50
Contact Hrs./Sem.	13	0	26	0	0	0	0	SEE Marks	50
Credits	1		1						
Total Contact Hrs.	**39**							Total Marks	100

Course Objective: The objective of this course is to provide hands-on experience for use of modern tools for performing statistical analysis, managing construction projects, design of intersections, highway design, pavement analysis, pavement evaluation, embankment slope stability analysis and town planning.

Course Outcomes (COs): At the end of this course, the student will be ableto	
CO1	Use statistical tools to perform the analysis of the data set.
CO2	Use project management tools for handling construction projects.
CO3	Use modern tool for the design of intersections and traffic simulation.
CO4	Use modern tools for the design, analysis and evaluation of pavements.
CO5	Prepare MS Excel spread sheets for the estimation of quantity and cost of road projects.

1. Statistical software – SPSS, Minitab **6 Hrs.**

2. Project Management software – MS Project, Primavera **6 Hrs.**

3. Traffic related software – VISSIM **4 Hrs.**

4. Geometric design and Highway –Civil 3D **12 Hrs.**

5. Pavement evaluation software – HDM 4 **6 Hrs.**

6. Quantity and Cost estimation of Road projects **–** MS Excel Spread Sheet **5 Hrs.**

REFERENCE BOOKS:

1	Relevant IRC codes of practice and user manuals.