COEP Technological University

(Unitary Public University of Government of Maharashtra)

Wellesely Road, Shivajinagar, Pune - 411005

Department of Civil Engineering

Curriculum

(Structure, Evaluation Scheme and Course Content)

For

Post Graduate Program

Master of Technology

In

Transportation Engineering

With Effect From

Academic Year 2025-2026

Program Educational Objectives

I. Graduates of the program will have in-depth knowledge to identify and formulate challenging problems in transportation engineering, apply appropriate research methodologies, use modern engineering tools and provide technically sound, economical and sustainable solutions.

II. Graduates will have the ability for higher studies and undertake high value research on transportation engineering and other related issues.

III. Graduates of the program will have sound analytical and lateral thinking ability to engage in lifelong learning for professional advancement to cope up with multidisciplinary and changing technologies in transportation engineering.

IV. Graduates of the program will have a sense of social responsibility, will demonstrate the ability to communicate and work effectively as a team member in an ethical way, and will play leadership roles in their profession, public services and community.

Program Outcomes

On completion of the program students will be able to

PO1: Apply the knowledge of science, mathematics, and engineering principles for developing problem solving attitude, independently carrying out research /investigation and development works.

PO2: Write and present a substantial technical report / document.

PO3: Demonstrate a degree of mastery in transportation engineering. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO4: Gain knowledge / skill in transportation engineering for collaborative multidisciplinary solutions and carry out planning and management of projects as a member and a leader in a team considering economic and financial factors.

PO5: Recognize the need for and have ability in lifelong learning independently for professional advancement, demonstrate professional ethics, work culture and understanding of responsibility to contribute to community for sustainable development of society.

Correlation between the PEOs and the POs

	PO 1	PO 2	PO 3	PO 4	PO 5
PEO 1	3	2	3	2	2
PEO 2	3	2	3	1	3
PEO 3	2	1	2	1	3
PEO 4	1	3	1	3	3

Master of Technology

Transportation Engineering Curriculum Structure

List of Abbreviations

Abbreviation	Title	No of courses	Credits	% of Credits
PSMC	Program Specific Mathematics Course	1	4	5.0
PSBC	Program Specific Bridge Course	1	3	3.75
PEC	Program Elective Course	3	9	11.25
MLC	Mandatory Learning Course	2	0	0.0
PCC	Program Core Course	6	20	25.00
LC	Laboratory Course	2	4	5.00
UOE	University Open Elective	1	3	3.75
LLC/CCA	Liberal Learning Course/ Co-curricular & Extracurricular Activities (CCA)	1	1	1.25
SLC	Self-Learning Course	2	6	7.5
SBC	Skill Based Course	3	25	31.25
RM/AEC		2	5	6.25

Curriculum Structure for M. Tech. Transportation Engineering NEP Effective from 2025-26

Semester I

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
1.	PSMC	CTE-25001	Probability and Data Analysis	**3**	**1**	**-**	**1**	**4**	**30**	**20**	**50**	**-**	**-**
2.	PSBC	CTE-25002	Traffic Engineering and Management	**2**	**-**	**2**	**1**	**3**	**30**	**20**	**50**	**50**	**50**
3.	PCC	CTE-25003	Highway Geometric Design	**3**	**1**		**1**	**4**	**30**	**20**	**50**		
4.	PCC	CTE-25004	Highway Materials	**3**	**-**	**-**	**1**	**3**	**30**	**20**	**50**		
5.	PCC	CTE-25005	Highway Geotechnology	**3**	**-**	**-**	**1**	**3**	**30**	**20**	**50**		
6.	LC	CTE-25006	Transportation Engineering Lab I	**-**	**-**	**4**	**-**	**2**				**50**	**50**
7.	PEC-1	CTE(PE)-25001 CTE(PE)-25002 CTE(PE)-25003 CTE(PE)-25004 CTE(PE)-25005	Low Volume Roads Sensors and Automation Advances in Docks and Harbor Engineering Airport Infrastructure Planning and Design Application of Geoinformatics in Transportation Engineering	**3**	**-**	**-**	**1**	**3**	**30**	**20**	**50**	**-**	**-**
8	RM	<tbd>	Research Methodology	**2**	**1**	**-**	**1**	**3**	**30**	**20**	**50**	**-**	**-**
Total Credits				**25**									

Legends: L-Lecture, T-Tutorial, P-Practical, S-Self Study, Cr-Credits,

ISE: In-Semester-Evaluation, ESE: End-Semester-Evaluation, MSE: Mid-Semester Evaluation, TA: Teacher's Assessment, CIE: Continuous-Internal-Evaluation

Semester II

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
1.	OE	<tbd>	Open elective	**3**	**-**	**-**	**1**	**3**	**30**	**20**	**50**	-	-
2.	PCC	**<tbd>**	Analysis and Design of Pavement	**3**	**-**	**2**	**1**	**4**	**30**	**20**	**50**	**50**	**50**
3.	PCC	**<tbd>**	Traffic Flow Modelling and Simulation	**3**	**-**	**-**	**1**	**3**	**30**	**20**	**50**		
4.	PCC	**<tbd>**	Highway Structures	**3**	**-**	**-**	**1**	**3**	**30**	**20**	**50**		
5.	PEC-2	<tbd>	• Sustainable Construction Engineering • Advanced Optimization Techniques in Transportation Engineering • Pavement Construction and Evaluation • Rail and Metro Construction • Freight Transportation Planning and Logistics • Intelligent Transportation Systems • Any course approved by BOS	**3**	**-**	**-**	**1**	**3**	**30**	**20**	**50**	**-**	**-**
6.	PEC-3	<tbd>	• Applications of AIML in Transportation Engineering • Road Safety and Road Safety Audit • Sustainable Transportation • Design of Underground Structure • Public Transportation Planning • Highway Financing and Policy Analysis • Any course approved by BOS	**3**	**-**	**-**	**1**	**3**	**30**	**20**	**50**	**-**	**-**
7.	**LC**	<tbd>	Transportation Engineering Lab II	**-**	**-**	**4**	**-**	**2**				**50**	**50**
8.	AEC	<tbd>	Technical Communication Skills	**1**	**-**	**2**	**1**	**2**	**50**	**50**	**-**	**100**	**-**
9.	LLC	<tbd>	Liberal Learning Course	**-**	**-**	**2**	**2**	**1**	**-**	**-**	**-**	**100**	**-**
Total Credits				**24**									

Semester III

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
1	SLC	<tbd>	Massive Open Online Course –I	3	-	-	1	3	-	-	100	-	-
2	SLC	<tbd>	Massive Open Online Course –II	3	-	-	1	3	-	-	100	-	-
3	OJT	<tbd>	Internship	-	-	-	-	3	-	-	100	-	-
4	Project	<tbd>	Dissertation Phase – I	-	-	22	12	11	-	-	-	70	30
Total Credits								20					

Semester IV

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
1	Project	<tbd>	Dissertation Phase – II	-	-	22	12	11	-	-	-	70	30
Total Credits								11					

Semester I

Civil Engineering Department
Post Graduate Syllabus Structure 2025-26

M. Tech Transportation Engineering

First Year

Semester I

Probability and Data Analysis

Course Code:		**Credit: 4**	
Teaching Scheme: Hrs/Week		**Examination Scheme:**	
Lectures:	3	MSE:	30
Tutorial:	1	TA:	20
Self-Study:	2	ESE:	50

Course Outcomes: At the end of the course, the students demonstrate the ability to:

1. Acquire skills to perform engineering research using statistical methods and becoming capable of estimating mathematical expectations.
2. Learn the fundamental concepts of set theory and interpret probability and data distribution functions.
3. Analyze regression and correlation analysis and development of statistical models.
4. Acquire theoretical knowledge on setting hypothesis for pattern recognition.
5. Apply suitable machine learning techniques for data handling and to gain knowledge from it.

Unit 1: Introduction to Statistical Methods [8 Hrs]
Statistical methods, scope and limitations, Frequency distributions, Graphic representation, Measures of central tendency, Partition values, Graphical location of partition values, Measures of dispersion, skewness and kurtosis

Unit 2: Theory of Probability [8 Hrs]
Introduction, Mathematical tools, Axiomatic approach, Probability function, Multiplication law of probability and conditional probability, Bayes theorem, Random variable, Distribution function, Probability density function

Unit 3: Correlation and Regression [8 Hrs]
Curve fitting, Principle of least squares, Karl Pearson coefficient of correlation, Probable error of correlation coefficient, Rank correlation, Regression, Correlation ratio, Intra-class correlation, Bivariate normal distribution

Unit 4: Sampling and Statistical Inference [8 Hrs]
Sampling -Introduction and types, Tests of significance, Null hypothesis, Errors in sampling, Chi-square distribution, t-distribution, F-distribution, Likelihood ratio test, Mann-Whitney-Wilcoxon U-test

Unit 5: Statistical Machine Learning Techniques [8 Hrs]
Linear regression, Logistic regression, Decision trees, Random forest, Support vector machines (SVM), K- nearest neighbors (KNN), Neural network, Kernal function, K-means clustering, K-mode clustering, Genetic algorithm

Unit 6: Self-Study
Mean, Median, Mode, Frequency tables, Histograms, Theoretical and experimental probability, Basic probability rules including sample spaces and events, Concept of random variables, Combinations and permutations, Probability distributions, Different sampling methods, Hypothesis testing, Predictive models, Stochastic Processes, Learning Models, Supervised and unsupervised learning, Study of different statistical machine learning techniques, Study of statistical techniques using software such as MATLAB, R Programming

Textbooks:

[1] D. C. Montgomery and G. C. Runger, Applied Statistics and Probability for Engineers, 5th Edition, John Wiley & Sons, Inc., NY, USA, 2011

[2] S. C. Gupta and V. K. Kapoor, Fundamentals of Mathematical statistics, Sultan Chand and Sons, 1978.

[3] Alpaydin, Introduction to Machine Learning, MIT Press.

[4] Masashi Sugiyama**,** Introduction to Statistical Machine Learning, Elsevier, USA, 2016

Reference Books:

[1] S. M. Ross, Introduction to Probabiltity Models,8th edition. Academic Press, 2004

[2] Mitchell, Machine Learning, McGraw Hill.

[3] Glen Cowan, Statistical Data Analysis, Clarendon Press , Oxford, 1998

[4] S. Dowdy, S. Wearden, and D. Chilko, Statistics for Research, Wiley, 2nd ed, 2004.

eb Resources:

[1] Probability and Statistics by Prof. Somesh Kumar, IIT Kharagpur (NPTEL) https://onlinecourses.nptel.ac.in/noc21_ma74/preview

[2] Introduction to Statistics by Prof. Sameen Naqvi, IIT Hyderabad (NPTEL) https://onlinecourses.nptel.ac.in/noc24_ma30/preview

[3] Statistical Inference by Prof. Niladri Chatterjee, IIT Delhi (NPTEL) https://onlinecourses.nptel.ac.in/noc20_ma19/preview

[4] Introduction to Machine Learning by Prof. Balaraman Ravindran, IIT Madras (NPTEL) https://onlinecourses.nptel.ac.in/noc22_cs29/preview

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	2	3	1	2
CO2	**3**	1	2	1	2
CO3	**3**	2	3	2	2
CO4	**3**	1	2	1	2
CO5	**3**	2	3	2	3

1 – Slightly; 2 – Moderately; 3 – Substantially

Traffic Engineering and Management

Course Code:		**Credit: 3**	
Teaching Scheme:	Hrs/Week	**Examination Scheme:**	
Lectures:	2	MSE:	30
Practical:	2	TA:	20
Self-Study:	1	ESE:	50

Course Outcomes: At the end of the course, the students demonstrate the ability to:

CO 1: Interpret Traffic Stream Characteristics and Sensing Technologies

CO 2: Analyse Traffic Volume and Fundamental Flow Relationships

CO 3: Interpret Traffic Flow Parameters and Capacity Concepts

CO 4: Demonstrate Traffic Intersection Control and Traffic Signal Design Principles

CO 5: Conduct Specialized Traffic Studies, including Parking Analysis and Shockwave Propagation

Unit 1: Traffic stream characteristics [8 Hrs]

Introduction, Human-vehicle-environment system, Road user and vehicle characteristics, Traffic Sensing Technologies: Traffic Sensors, Traffic Sensor Classification, Data Sources: Mobile Sensor Data, Point Sensor Data, Space Sensor Data, Time-Space Diagram and Characteristics: Time and space headways, gaps, clearance, temporal, spatial and flow patterns; speed characteristics, Traffic Volume: Computation of Annual Average Daily Traffic (AADT), Annual Average Weekly Traffic (AAWT), Average Daily Traffic (ADT), Average Weekly Traffic (AWT), Design Hourly Volume from Short and Long Term Counts to develop adjustment factors, Fundamental traffic flow relationships, Moving observer method

Unit 2: Traffic Flow Analysis [8 Hrs]

Time Headways, Traffic Stream Parameters and their Relationships, Single-Regime Models, Multi-Regime Models, Concept of Capacity and Level of Service for Basic Freeway Segments, Multilane Highways, two lane highways as per Highway Capacity Manual (HCM) (2016), Analysis of Capacity and LOS of single, intermediate two lane and multi lane highways as per Indian Highway Capacity Manual (Indo-HCM) (2017)

Unit 3: Traffic intersection control [8 Hrs]

Principles of Traffic Control and Traffic Signs, Road Markings and Channelization, Uncontrolled Intersection: Gap acceptance and capacity concepts, Uncontrolled Intersection: Capacity and LOS analysis, Traffic Rotaries and Grade Separated Intersection

Unit 4: Traffic Signal Design [6 Hrs]

Design Principles of Traffic Signal, Evaluation of a Traffic Signal: Delay Models, Capacity and LOS Analysis of a Signalized I/S, Coordinated Traffic Signal, Vehicle Actuated Signals and Area Traffic Control

Unit 5: Specialized traffic studies [6 Hrs]

Shockwave analysis: Qualitative Analysis, Quantitative Analysis, Propagation of Shockwave, Car following models, traffic microsimulation, Parking Studies, Parking inventory, Statistics, Parking surveys; in out license palate, On-street and off-street parking

Unit 6: Self-Study

Moving Observer Method and compare with modern floating car data, Explore Indo-HCM 2017 guidelines for capacity and LOS of Indian highways, Review successful grade-separated intersections in urban India (flyovers, cloverleaf), coordinated signals (green wave concept) with case studies., parking management strategies (pricing, smart parking, ITS integration).

Textbooks:

- Kadiyali, L.R. – *Traffic Engineering and Transport Planning*, Khanna Publishers, New Delhi.
- Khanna, S.K. & Justo, C.E.G. – *Highway Engineering*, Nem Chand & Bros., Roorkee.
- Subramanian, K.P. – *Traffic Engineering and Management*, Scitech Publications, Chennai.
- Roess, R.P., Prassas, E.S. & McShane, W.R. – *Traffic Engineering*, Pearson Education.
- May, A.D. – *Traffic Flow Fundamentals*, Prentice Hall.
- Garber, N.J. & Hoel, L.A. – *Traffic and Highway Engineering*, Cengage Learning.
- Papacostas, C.S. & Prevedouros, P.D. – *Transportation Engineering and Planning*, Pearson.

Reference Books:

- Indian Roads Congress (IRC) Codes:
- IRC:65 – Recommended Practice for Traffic Rotaries.
- IRC:67 – Code of Practice for Road Signs.
- IRC:93 – Guidelines for Design of Traffic Signals.
- Indo-HCM (2017) – *Indian Highway Capacity Manual*.
- Highway Capacity Manual (HCM 2016) – Transportation Research Board, USA.
- Drew, D.R. – *Traffic Flow Theory and Control*, McGraw Hill.
- Levinson, H.S. – *Traffic Flow and Transportation: Theory and Applications*.
- Wong, Y.D. & Lam, W.H.K. – *Transport Simulation and Network Modelling*.
- Banks, J.H. – *Introduction to Transportation Engineering*, McGraw Hill.
- Oppenlander, J.C. & Richter, A.M. – *Traffic Flow and Transportation*.

:b ReWebsources:

- *Traffic Engineering*, *Highway Engineering*, *Urban Transportation Systems*. https://onlinecourses.nptel.ac.in/noc21_ma74/preview
- Transportation systems analysis and urban traffic management. https://ocw.mit.edu
- Case studies of ITS and smart traffic management. https://smartcities.gov.in

List of Laboratory Experiments

A. Mandatory

1. Space mean speed data analysis
2. Capacity analysis of urban highway using Greenshield's model
3. Capacity analysis of Signalized Intersection as per Indo-HCM (2017)

B. Perform any five.

1. Speed data analysis using Geotracker.
2. Capacity analysis of Roundabout as per Indo-HCM (2017)
3. Signal Design by Websters Method or Indo-HCM (2017)
4. Origin-Destination Studies
5. Home interview Survey
6. Moving Observer Method
7. Headway analysis

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	1	3	1	2
CO2	**3**	2	3	2	2
CO3	**3**	2	3	2	2
CO4	**2**	2	3	3	2
CO5	**3**	2	3	2	3

1 – Slightly; 2 – Moderately; 3 – Substantially

Highway Geometric Design

Course Code:		**Credit: 4**	
Teaching Scheme: Hrs/Week		**Examination Scheme:**	
Lectures:	3	MSE:	30
Tutorial:	1	TA:	20
Self-Study:	1	ESE:	50

Course Outcomes: At the end of the course, the students demonstrate the ability to:

CO 1: Analyze design controls such as traffic, speed, topography, and safety in highway geometric design.

CO 2: Design cross-section elements of highways and urban streets including pedestrian and bicycle facilities.

CO 3: Apply principles of horizontal and vertical alignment to design curves, gradients, and sight distance requirements

CO 4: Evaluate intersection layouts, channelization, and ramp facilities for safe and efficient traffic operations.

CO5: Develop design for parking areas, bus/truck terminals, toll plazas and pedestrian facilities

Unit 1: Introduction **[8 Hrs]**

Design Controls - Topography and physical features, traffic, vehicular characteristics, speed and safety; Space standards for urban, rural and hill roads, Sight distance requirements, Access controls

.

Unit 2: Cross-section Elements **[8 Hrs]**

Single lane, Two lane, Multi-lane highways, Expressways, Urban roads; Street design concepts, bicycle tracks, pedestrian facilities, street furniture, Design of Speed Breaker.

Unit 3: Alignment **[8 Hrs]**

Horizontal Alignment - Curve design, Super-elevation design, Transition curve design, Attainment of super-elevation, Pavement widening, Sight distance on horizontal curves; Vertical Alignment - Gradients, Grade compensation, Design of vertical curves, Combination of horizontal and vertical alignment, vertical clearance for underpasses and elevated structures

Unit 4: Intersection Geometry **[8 Hrs]**

Visibility requirements, Principles of channelization, Layout design for types of intersections, on-ramps and off-ramps (flyovers and Access controlled facilities), Acceleration and deceleration lanes, Two-way tum lanes.

Unit 5: Design of Facilities **[8 Hrs]**

Design of on-street and off-street parking facilities, multi-storyed Parking; Design of bus shelters and bus lay-bye, Bus terminal, Truck terminals and truck layby, Container terminal, Toll Plaza, Foot-over bridge and sky-walk

Unit 6: Self-Study

Case study of expressways, freeways, and access-controlled highways. Driver behavior, perception-reaction time, and its impact on design controls. Design of roundabouts, diverging diamond interchanges (DDI), turbo roundabouts, and SPUI (Single Point Urban Interchanges). Context Sensitive Solutions (CSS) and Complete Streets approach.

Textbooks

Khanna, S.K. & Justo, C.E.G. – *Highway Engineering*, Nem Chand & Bros., Roorkee.

Kadiyali, L.R. – *Traffic Engineering and Transport Planning*, Khanna Publishers, New Delhi.

Partha Chakroborty & Animesh Das – *Principles of Transportation Engineering*, Prentice Hall of India.

S.K. Sharma – *Principles, Practice and Design of Highway Engineering*, S. Chand & Co.

Reference Books

1. AASHTO Green Book – *A Policy on Geometric Design of Highways and Streets*, American Association of State Highway and Transportation Officials.
2. Highway Capacity Manual (HCM 2016) – Transportation Research Board, USA.
3. Indian Roads Congress (IRC) Standards:
    - IRC: 38 – Guidelines for Design of Horizontal Curves.
    - IRC: 67 – Code of Practice for Road Signs.
    - IRC: 73 – Geometric Design Standards for Rural (Non-Urban) Highways.
    - IRC: 86 – Geometric Design Standards for Urban Roads.
    - IRC: SP:41 – Guidelines for Design of At-Grade Intersections.
    - IRC: SP:84 – Manual of Specifications and Standards for Four-Laning of Highways.
4. O'Flaherty, C.A. (Ed.) – *Highway Engineering*, Edward Arnold, London.
5. Wright, P.H. & Dixon, K.K. – *Highway Engineering*, Wiley.
6. Garber, N.J. & Hoel, L.A. – *Traffic and Highway Engineering*, Cengage Learning.
7. Papacostas, C.S. & Prevedouros, P.D. – *Transportation Engineering and Planning*, Pearson.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	1	**3**	2	2
CO2	**3**	2	**3**	**3**	2
CO3	**3**	2	**3**	**3**	2
CO4	**3**	2	**3**	**3**	2
CO5	**2**	2	**3**	**3**	2

1 – Slightly; 2 – Moderately; 3 – Substantially

Highway Materials

Course Code:		**Credit: 3**	
Teaching Scheme: Hrs/Week		**Examination Scheme:**	
Lectures:	3	MSE:	30
Tutorial:		TA:	20
Self-Study:	1	ESE:	50

Course Outcomes: At the end of the course, the students demonstrate the ability to:
CO 1: Describe various pavement materials
CO 2: Compare conventional and advanced characterisation of pavement materials
CO 3: Design practical solution to Mix design of Pavement Materials
CO 4: Interpret recycled waste products

Unit 1: Aggregate **[8 Hrs]**
Nature and properties, aggregate requirements, Types and processing, Aggregates for pavement base, Aggregate for bituminous mixture, Aggregate for Portland Cement Concrete, Light weight aggregate, Tests on aggregate, Specification.

Unit 2: Bituminous Materials **[8 Hrs]**
Conventional and modified binders production, Types and grade, Physical and chemical properties and uses, Types of asphalt pavement construction, Principles of bituminous pavement construction, Tests on bituminous materials

Unit 3: Bituminous Mix design **[8 Hrs]**
Bituminous Mix design, Modified mixtures, Temperature susceptibility and performance. Cement /concrete based materials, Cement properties, PCC mix design and properties, Modified PCC, Mix Design behaviour, Performance, Tests on Cement and Concrete mixes. High Performance Concrete, Low shrinkage, Increased strength. Composites, Plastics and Geosynthetics: Plastics and polymerization process, Properties, Durability and Chemical composition, Reinforced Polymer Composites, Geosynthetics, Dry Powdered Polymers, Enzymes

Unit 4: Reclaimed/Recycled Waste Products **[6 Hrs]**
Reclaimed Materials, Waste products in civil engineering applications, Effect of waste products on materials, Structure and properties, self-healing and smart materials, Locally available materials

Unit 5: Modern and Advanced Pavement Materials **[6 Hr]**
Composite materials in pavements, Plastics and polymerization process – properties, durability, chemical composition, Reinforced polymer composites Geosynthetics in pavement applications, Dry powdered polymers and enzymes, Innovative and sustainable binders

Unit 6: Self-Study
Rheological properties of binders, Nano-materials in pavement engineering, Carbon footprint of pavement materials, Use of industrial by-products (slag, fly ash, silica fume), Case studies of innovative pavements in India and abroad.

Text Books

1. Khanna, S.K., & Justo, C.E.G. (2019). *Highway Engineering*. Nem Chand & Bros.
2. Khanna, S.K., Justo, C.E.G., & Veeraragavan, A. *Highway Materials and Pavement Testing*. Nem Chand & Bros.
3. Huang, Y.H. (2004). *Pavement Analysis and Design*. Pearson.
4. Roberts, F.L., Kandhal, P.S., Brown, E.R., Lee, D-Y., & Kennedy, T.W. (1996).
5. *Hot Mix Asphalt: Materials, Mixture Design and Construction*. NAPA Research and Education Foundation
6. Neville, A.M. (2011). *Properties of Concrete*. Pearson.

Reference Books

1. Indo-HCM (2017). *Indian Highway Capacity Manual*. IRC, New Delhi.
2. MoRTH (2020). *Specifications for Road and Bridge Works*. Ministry of Road Transport and Highways, Government of India.
3. IRC Codes (Latest Revisions):
    - IRC: 37 – Guidelines for the Design of Flexible Pavements
    - IRC: 58 – Guidelines for the Design of Rigid Pavements
    - IRC: SP: 53 – Guidelines on Use of Polymer and Rubber Modified Bitumen
    - IRC: SP: 89 – Guidelines for Use of Geotextiles in Road Pavements
4. Read, J., & Whiteoak, D. (2003). *The Shell Bitumen Handbook*. Thomas Telford.
5. Brown, E.R. & Kandhal, P.S. *Hot Mix Asphalt Materials, Mixture Design, and Construction*. NAPA.
6. Mamlouk, M.S., & Zaniewski, J.P. (2011). *Materials for Civil and Construction Engineers*. Pearson**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**2**	1	**2**	1	2
CO2	**3**	2	**3**	2	2
CO3	**3**	2	**3**	**3**	2
CO4	**2**	1	**2**	2	**3**

1 – Slightly; 2 – Moderately; 3 – Substantially

Highway Geotechnology

Course Code:		**Credit: 3**	
Teaching Scheme: Hrs/Week		**Examination Scheme:**	
Lectures:	3	MSE:	30
Tutorial:		TA:	20
Self-Study:	1	ESE:	50

Course Outcomes: At the end of the course, the students demonstrate the ability to:

CO 1: Demonstrate different terminologies related to highway geotechnology

CO 2: Identify the soil and its suitability for different uses

CO 3: Analyze the strength, stability of soil for embankments/cuts and pavements

CO 4: Evaluate and design the slopes, drainage and foundation.

CO 5: Decide suitability of rock for different structures

Unit 1: Classification of Soil and Highway Drainage **[8 Hrs]**

Significance of soil classification in the context of transportation engineering. Particle size classification, HRB classification, Group index method, USCS and ISCS Classification. Introduction and importance of highway drainage system. Subsoil drainage techniques tailored for highway engineering. Methods of drainage for roads: surface and subsurface drainage systems.

Unit 2: Shear Strength **[8 Hrs]**

Introduction, Stress at a point, Mohr-Coulomb failure criteria, Measurement of shear strength, Shear strength of soil-mass, Drainage conditions and shear strength parameters, Stress paths, Pore water pressure, Shear parameters and shear strength.

Unit 3: Stability Analysis of Slopes **[8 Hrs]**

Introduction, Slope stability for transportation infrastructures, Factor of safety, Infinite slopes and translational slides, Finite slopes – Forms of slip surface, Limiting Equilibrium method and critical stages in stability, Stability of finite slopes, Taylors stability number, Method of Slices

Unit 4: Geotechnical Aspects in Pavement and Foundation **[8 Hrs]**

Introduction to flexible and rigid pavement, Soil stabilization of soil subgrade. Introduction to foundations for different substructures, General requirements of foundations, Location and Depth of foundation, Bearing capacity of shallow foundations. Uses of piles, Types of piles, Driven piles and bored cast in-situ piles, Pile load carrying capacities and well Foundation.

Unit 5: Rock Mechanics **[8 Hrs]**

Fundamental of rock mechanics; Rock properties; Rock mass classification systems, Comparison of rock mass classification schemes, RQD index as a qualitative description of the rock mass, Limitations and advantages. Geo- investigation and exploration Methods

Unit 6: Self-Study

Importance of compaction for different transportation infrastructure. Mechanics of compaction. Lab tests and field tests. Compaction equipment based on the type of soil and field requirements. Quality control and measurement techniques for achieving optimal compaction in transportation engineering. Behavior of compacted geomaterials.

References

[1] Ranjan, G., & Rao, A. S. R. (2016). Basic and applied soil mechanics. New Age International.

[2] Das, B. M. (2021). Principles of geotechnical engineering. Cengage learning.

[3] Hudson, J. A., & Harrison, J. P. (2000). Engineering rock mechanics: an introduction to the principles. Elsevier.

[4] Jaeger, J. C., Cook, N. G., & Zimmerman, R. (2009). Fundamentals of rock mechanics. John Wiley & Sons.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**2**	1	2	1	2
CO2	**3**	1	**3**	2	2
CO3	**3**	2	**3**	2	2
CO4	**3**	2	**3**	**3**	2
CO5	**3**	1	**2**	2	2

1 – Slightly; 2 – Moderately; 3 – Substantially

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Transportation Engineering Lab I

Course Code:	**Credit: 4**
Teaching Scheme: Hrs/Week	**Examination Scheme:**
Practical: 2	ISE: 50
Tutorial:	
Self-Study:	ESE: 50

Course Outcomes: At the end of the course, the students demonstrate the ability to:

CO 1: Apply relevant national and international codes for performing new experiments in Transportation laboratory

CO 2: Develop skills in performing experiments related to Transportation engineering and correlate with the quality standards

CO 3: Exercise hands on experience to develop higher level motor skills

CO 4: Analyse Traffic Volume and Fundamental Flow Relationships

CO5: Demonstrate Traffic Intersection Control and Traffic Signal Design Principles

A) List of Laboratory Experiments (Minimum 8)

Students will perform various sets of experiments in the Transportation laboratory as decided by the Laboratory In-charge and write a test report as a part of Laboratory work.

Tests on Aggregate: gradation, shape tests, specific gravity, water absorption, aggregate crushing value, Los Angeles abrasion value, aggregate impact value.

Tests on Bitumen: penetration, viscosity by Brookfield Rotational Viscometer, flash and fire point, ductility and elastic recovery, softening point, specific gravity, Ageing of Bitumen: Rolling Thin Film Oven Test (Short Term) and Pressure Ageing Vessel (Long Term), Multiple Stress Creep and Recovery test using Dynamic Shear Rheometer, Linear Amplitude Sweep (LAS) test.

Tests on Bituminous Mixes: Marshall mix design, Bitumen content determination using centrifuge extractor.

Non-Destructive Tests: Benkelman Beam, Bump Indicator

C. Field visits for studying Transportation Engineering

B) Mandatory

1. Space mean speed data analysis
2. Capacity analysis of urban highway using Greenshield's model
3. Capacity analysis of Signalized Intersection as per Indo-HCM (2017)

References

Highway Material Testing Laboratory Manual by Khanna S. K., Justo, C.E.G and Veeraraghavan, A., Nem Chand & Bros.

Various IRC, ASTM and AASTHO Codes

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	1	**3**	1	2
CO2	**3**	2	**3**	2	2
CO3	**2**	1	**2**	2	2
CO4	**3**	2	**3**	2	2
CO5	**3**	2	**3**	**3**	2

1 – Slightly; 2 – Moderately; 3 – Substantially

PEC-I-- Low Volume Roads

Course Code:		**Credit: 3**	
Teaching Scheme: Hrs/Week		**Examination Scheme:**	
Lectures:	3	MSE:	30
Tutorial:		TA:	20
Self-Study:	1	ESE:	50

Course Outcomes: At the end of the course, the students demonstrate the ability to:

CO 1: Interpret rural road network plan

CO 2: Evaluate appropriate materials for construction of low volume roads considering cost effectiveness

CO 3: Design flexible pavement and rigid pavement for low volume roads.

CO 4: Determine the provision of an appropriate road drainage system

CO 5: Apply an appropriate construction technique with relevant quality control tests

Unit 1: Planning of Rural Road Network **[8 Hrs]**

Significance of rural road network, Characteristics of low volume roads, Features of PMGSY, MMGSY, Network planning of low volume road

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Unit 2: Pavement Materials for Low Volume Roads **[8 Hrs]**

Soil Investigations, Properties and Specifications of materials for different layers, utilization of locally available materials in village road projects, marginal materials, non-conventional materials, stabilized roads.

Unit 3: Design of Pavements for Low Volume Roads **[8 Hrs]**

Design factors, pavement thickness design as per IRC, design of Semi-rigid pavement, roller compacted cement concrete pavement, special pavements like interlocking- block paving, design of fly ash embankments

Unit 4: Road Drainage **[8 Hrs]**

Types of drainage, surface, and sub-surface drains for low volume roads.

Unit 5: Construction Practices for Low Volume Roads **[8 Hrs]**

Specifications for embankment, subgrade, sub-base, base course and surface course, Construction procedures, Construction equipment, Construction of special pavements for low volume roads

Unit 6: Self study

Case studies of roads built with unconventional/marginal materials, Low-carbon construction practices, Low-carbon construction practices, Role of rural roads in mitigating climate impacts (floods, heat), Successful models of rural road development improving connectivity, economy, and social equity.

Textbooks

1. Khanna, S.K., Justo, C.E.G. & Veeraragavan, A. – *Highway Engineering* – Nem Chand & Bros., Roorkee.
2. Kadiyali, L.R. & Lal, N.B. – *Principles and Practices of Highway Engineering* – Khanna Publishers, New Delhi.
3. Yang H. Huang – *Pavement Analysis and Design* – Pearson.
4. Murthy, V.N.S. – *Soil Mechanics and Foundation Engineering* – CBS Publishers.
5. Vaswani, N.K. – *Highway Engineering* – Wiley Eastern.

Reference Books

1. IRC:SP:20-2002 – *Rural Roads Manual* – Indian Roads Congress, New Delhi.
2. IRC:SP:72-2015 – *Guidelines for the Design of Flexible Pavements for Low Volume Rural Roads*.
3. IRC:SP:77-2018 – *Manual for the Design, Construction and Maintenance of Gravel Roads*.
4. MoRD (Ministry of Rural Development, India) – *Specifications for Rural Roads & PMGSY Guidelines*.
5. Overseas Road Note 31 – *A Guide to the Structural Design of Bitumen-Surfaced Roads in Tropical and Sub-Tropical Countries*, Transport Research Laboratory (TRL), UK.
6. Overseas Road Note 20 – *Management of Low-Volume Roads*.
7. World Bank Technical Papers – *Low-Volume Rural Road Guidelines*.
8. ADB (Asian Development Bank) – *Handbook on Rural Road Development*.
9. FAO (Food and Agriculture Organization) – *Rural Roads and Bridges Design and Construction*.
10. Gillespie, T.D. – *Fundamentals of Vehicle Dynamics* – SAE (for vehicle-road interaction on low volume roads).

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	1	2	2	1
CO2	3	1	3	2	1
CO3	3	1	3	2	1
CO4	3	1	3	2	1
CO5	3	1	3	3	2

1 – Slightly; 2 – Moderately; 3 – Substantially

PEC-I- Sensors and Automation

Course Code:		**Credit: 3**	
Teaching Scheme: Hrs/Week		**Examination Scheme:**	
Lectures:	3	MSE:	30
Tutorial:		TA:	20
Self-Study:	1	ESE:	50

Course Outcomes: At the end of the course, the students demonstrate the ability to:

CO1: Recognize the working of commonly used sensors for measurement of temperature, position, accelerometer, vibration sensor, flow and level

CO 2: Identify the application of machine vision.

CO 3: Conceptualize signal conditioning and data acquisition methods.

CO 4: Comprehend smart sensors and their applications in automation systems

Unit 1: Fundamentals of Sensors and Transducers **[8 Hrs]**

Definition of sensors and transducers, Classification of transducers, Electrical transducers: advantages and disadvantages, Characteristics of measurement systems (accuracy, precision, sensitivity, resolution, etc.)

Unit 2: Measurement Techniques using Sensors **[8 Hrs]**

Displacement Measurement: Potentiometer, Linear Variable Differential Transformer (LVDT), Force Measurement: Strain gauges & load cells, Pressure Measurement: LVDT-based diaphragm, piezoelectric sensor, earth pressure cell, humidity sensor, Proximity Sensors: Inductive, capacitive, photoelectric; accelerometer and vibration sensors, Temperature Sensors: RTD, Thermocouple.

Unit 3: Advanced and Special-Purpose Sensors **[8 Hrs]**

IR sensors, optical sensors, corrosion sensors, Acoustic emission sensors, inertial sensors, fuel sensors, Imaging Sensors: CCD and CMOS, sensing & digitizing functions in machine vision, Basics of image processing and analysis for engineering applications

Unit 4: Smart Sensors and Signal Conditioning **[8 Hrs]**

Smart sensors: structure, components, and characteristics, Applications of smart sensors in engineering and industry, Signal Conditioning: Introduction, need for amplification, filtering, isolation, linearization, Functions of signal conditioning equipment

Unit 5: Data Acquisition and Industrial Automation **[8 Hrs]**

Data Acquisition Systems (DAS): Introduction, objectives, configuration, Analog & digital I/O, counters, timers, need for data conversion (ADC/DAC), Industrial Automation: Concept, necessity, components, block schematic of PLC, Input & Output modules (AI, DI, AO, DO), Introduction to Ladder Programming, basics of Distributed Control Systems (DCS), Linkage of industrial automation with Industrial IoT (IIoT) and Industry 4.0

Unit 6: Self study

Integration of sensors with IoT platforms (cloud & edge computing), Applications in smart cities, transportation, healthcare, and industrial monitoring.AI for sensor data interpretation. Basics of image processing and analysis. Role of sensors in cyber-physical systems.

Textbooks

1. D. Patranabis – *Sensors and Transducers* – PHI Learning.
2. S. Rangan, G.R. Sarma, V.S.V. Mani – *Instrumentation Devices and Systems* – Tata McGraw Hill.
3. John G. Webster & Halit Eren – *Measurement, Instrumentation, and Sensors Handbook* – CRC Press.
4. R.K. Jain – *Mechanical and Industrial Measurements* – Khanna Publishers.
5. Roman Kuc – *Introduction to Digital Signal Processing* – McGraw Hill (for signal conditioning & DAQ concepts).
6. Mikell P. Groover – *Automation, Production Systems, and Computer-Integrated Manufacturing* – Pearson.
7. D. Patranabis – *Principles of Industrial Instrumentation* – Tata McGraw Hill.
8. Frank D. Petruzella – *Programmable Logic Controllers* – McGraw Hill.

Reference Books

1. R.S. Khandpur – *Handbook of Analytical Instruments* – Tata McGraw Hill.
2. E.A. Parr – *Industrial Control Handbook* – Butterworth-Heinemann.
3. B.G. Lipták – *Instrumentation Engineers' Handbook* (Process Measurement and Analysis) – CRC Press.
4. D. Patranabis – *Instrumentation and Control* – PHI Learning.
5. Richard Zurawski (Ed.) – *Industrial Communication Technology Handbook* – CRC Press (for Industrial IoT & Industry 4.0).
6. Clarence W. de Silva – *Sensors and Actuators: Engineering System Instrumentation* – CRC Press.
7. Sabah Mohammed, Jinan Fiaidhi – *Industrial IoT: Technologies and Applications* – Springer.
8. K. Krishnamurthy & P. Banerjee – *Applications of Automation and Robotics in Road Transport* – Transportation Engineering Series (useful for case-based studies)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	1	2	1	1
CO2	3	1	2	2	1
CO3	3	1	3	2	1
CO4	3	1	3	3	2

1 – Slightly; 2 – Moderately; 3 – Substantially

PEC-I Advances in Docks and Harbour Engineering

Course Code:		**Credit: 3**	
Teaching Scheme: Hrs/Week		**Examination Scheme:**	
Lectures:	3	MSE:	30
Tutorial:		TA:	20
Self-Study:	1	ESE:	50

Course Outcomes: At the end of the course, the students demonstrate the ability to:
CO 1: Analyze global trade's impact on port planning
CO 2: Evaluate tide conditions, breakwaters, and navigability.
CO 3: Create and assess cargo handling and storage designs.
CO 4: Apply maintenance strategies to waterways
CO 5: Evaluate multi-modal transportation and Ro-Ro vessels

Unit 1: Introduction **[8 Hrs]**

Ports and harbours – an infrastructure layer between two transport media, planning of ports and harbours. Global Trade, GDP impact on EXIM trades, Traffic Studies, Introduction to Micro and Macro analysis Fundamentals: Tide and current conditions inside harbour, breakwaters, jetties and quay walls; mooring, berthing and ship motion inside the port; model studies, physical and mathematical studies. Design issues: Sea port layout with regards to (1) wave action (2) siltation (3) navigability, berthing facilities.

Unit 2: Design of Port Infrastructures **[8 Hrs]**

Design of port infrastructures with regards to (1) cargo handling (2) cargo storage (3) rail road connectivity, planning multipurpose port terminals:- Marine Oil Terminal, Passenger Terminals, Submarine pipe lines, Tank farms, Container Freight Stations, Port based SEZ, Concept of Dry Ports.

Unit 3: Port Operations **[8 Hrs]**

Types of Cargo handling and Equipment's, shipping lines for cargo operations, dredging and navigability, hazard scenarios; VTMS and management of computerized container terminal, safety & environment (handling of fire, oil spill, rescue, etc.)

Unit 4: Inland Waterways and Ports **[8 Hrs]**

Maintenance of waterways, construction of environmentally engineered banks, disposal processing and storing of polluted dredged materials, development of river transportation Functions of signal conditioning equipment

Unit 5: State of the Art Practices **[8 Hrs]**

Multi Modal Transportation, Ro-Ro vessels Custom Formalities, Dedicated freight Corridor, Case Studies. **Site Visits** (subject to obtaining approvals/permissions from concern authorities): - Mumbai Port/ JNPT , CWPRS, etc

Unit 6: Self study

Automation in cargo handling: automated cranes, driverless trucks, digital twins. Eco-friendly dredging methods and sediment management. Use of renewable energy (offshore wind, tidal, solar) in port operations. Design for sea level rise, extreme weather, storm surges. Resilient breakwaters, seawalls, and quay walls.

Textbooks

1. Oza, H. P., & Oza, G. H. – *Dock and Harbour Engineering* – Charotar Publishing.
2. Agerschou, H., et al. – *Planning and Design of Ports and Marine Terminals* – Thomas Telford, London.
3. Mehta, V. M. & Oza, H. P**.** – *Dock and Harbour Engineering* – Nirali Prakashan.
4. Sharma, R. C. & Kamal, M. – *A Textbook of Waterways, Harbours and Dock Engineering* – S. Chand & Co.
5. Basu, D. N. – *Harbour and Dock Engineering* – Oxford & IBH Publishing

Reference Books

1. PIANC Reports – Technical Reports on Port and Harbour Developments (International Navigation Association).
2. Permanent International Association of Navigation Congresses (PIANC) – *Guidelines for Sustainable Ports*.
3. United Nations Conference on Trade and Development (UNCTAD) – *Port Management Series* (various volumes).
4. World Association for Waterborne Transport Infrastructure (PIANC) Publications – covering dredging, inland navigation, and climate change resilience.
5. Burcharth, H. F., & Hughes, S. A**.** – *Design of Coastal Structures and Breakwaters*.
6. Sørensen, T. L. & Sorensen, J. D. – *Port and Harbour Risk Management*.
7. Wang, Jin & Meng, Qiang – *Maritime Logistics: A Guide to Contemporary Shipping and Port Management*.
8. UNCTAD & World Bank Reports – *Port Modernization, Smart Ports, and Global Trade Logistics*.
9. Case Studies from Major Ports – Singapore, Rotterdam, Hong Kong, and JNPT publications.
10. Research Papers – ASCE Journal of Waterway, Port, Coastal, and Ocean Engineering; Maritime Policy & Management Journal.l for case-based studies)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	1	2	3	2
CO2	3	1	3	2	1
CO3	3	1	3	3	1
CO4	3	1	2	2	1
CO5	3	1	2	3	2

1 – Slightly; 2 – Moderately; 3 – Substantially

PEC-I Airport Infrastructure Planning and Design

Course Code:		**Credit: 3**	
Teaching Scheme: Hrs/Week		**Examination Scheme:**	
Lectures:	3	MSE:	30
Tutorial:		TA:	20
Self-Study:	1	ESE:	50

Course Outcomes: At the end of the course, the students demonstrate the ability to:
CO 1: Analyse the requirement of airport layout with respect to international regulation
CO 2: Design Airport Pavement, Taxiway, and Apron.
CO 3: Assess cargo handling and VTMS implementation..
CO 4: Demonstrate visual aid required for safe landing and takeoff operation from passenger and cargo terminal
CO 5: Summarise the concept of the terminal service facility

Unit 1:Airport Planning **[8 Hrs]**

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

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Unit 2: Aircraft Characteristics **[8 Hrs]**

Landing gear configurations, aircraft weight, and engine types. Atmospheric conditions affecting aircraft performance: air pressure, temperature, wind speed, and direction. Aircraft performance characteristics: speed, payload, range, runway performance, declared distances, wingtip vortices. Air traffic separation rules: vertical separation, flight altitudes, longitudinal separation, and lateral separation. Navigational aids: ground-based systems, satellite-based systems

Unit 3: Geometric Design of the Airfield **[8 Hrs]**

Airport classification: utility airports, transport airports. Runways: runway configurations, runway orientation, the wind rose, estimating runway length, sight distance, and longitudinal profile, transverse gradient, airfield separation requirements, obstacle clearance requirements. Taxiways and taxi lanes: widths and slopes, taxiway and taxi lane separation requirements, sight distance and longitudinal profile, exit taxiway geometry, location of exit taxiways, design of taxiway curves and intersections, and end-around taxiways.

Unit 4: Structural Design of Airport Pavements **[8 Hrs]**

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

Unit 5: Planning And Design of the Terminal Area **[8 Hrs]**

Passenger terminal system and its components. Design considerations: terminal demand parameters, facility classification, level of service criteria. Terminal planning process: overall space requirements, concept development, horizontal distribution concepts, vertical distribution concepts. Apron gate system: number of gates, ramp charts, gate size, aircraft parking type, apron layout, apron circulation, passenger conveyance to aircraft, apron utility requirements. Requirements of visual aids, approach lighting system configurations, visual approach slope aids, threshold lighting. Runway lighting, taxiway lighting. Runway and taxiway marking, airfield signage.

Unit 6: Self study

ICAO guidelines on airport planning and design. DGCA (India) airport planning norms and CARs (Civil Aviation Requirements). Role of Airports Authority of India (AAI) in planning and development. Drone applications in airport operations (inspection, monitoring, traffic control).Case study of Navi Mumbai International Airport (greenfield airport planning in India)

References

[1] Ashford, N. J., Mumayiz, S. A., and Wright, P. H. Airport Engineering: Planning, Design and Development of 21st Century Airports, Fourth Edition, John Wiley & Sons, New Jersey, USA, 2011.

[2] Horonjeff, R., McKelvey, F. X., Sproule, W. J., and Young, S. B. Planning and Design of Airports, Fifth Edition, McGraw-Hill, New York, USA, 2010.

[3] Kazda, A., and Caves, R. E. Airport Design and Operation, Second Edition, Elsevier, Oxford, U.K., 2007.

[4] Khanna, S. K., Arora, M. G., and Jain, S. S. Airport planning and Design, Sixth Edition, Nem Chand and Bros, Roorkee, India, 2012.

[5] Kumar, V., and Chandra, S. Air Transportation Planning and Design, Galgotia Publications Pvt. Ltd., New Delhi, India, 1999.

[6] Neufville, R. D., and Odoni, A. Airport Systems: Planning, Design, and Management, McGraw-Hill, New York, USA, 2003.

[7] Young, S. B., and Wells, A. T. Airport Planning and Management, Sixth Edition, McGraw-Hill, New York, USA, 2011.

[8] "Port Engineering", 1st Edition, Gulf Publishing Company, 2000agement Journal.l for case-based studies)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	1	3	2	2
CO2	3	1	3	2	1
CO3	3	1	2	3	1
CO4	3	1	2	2	1
CO5	2	2	1	2	2

1 – Slightly; 2 – Moderately; 3 – Substantially

PEC I-Applications of Geoinformatics in Transportation Engineering

Course Code:	**Credit: 3**
Teaching Scheme: Hrs/Week	**Examination Scheme:**
Lectures: 3	MSE: 30
Tutorial:	TA: 20
Self-Study: 1	ESE: 50

Course Outcomes: Students will be able to:

1. Apply remote sensing principles to interpret multispectral satellite data for spatial and infrastructural analysis in transportation systems.
2. Analyze image processing techniques such as geometric and radiometric corrections to enhance the accuracy of spatial datasets.
3. Evaluate GIS functionalities for spatial data management, network analysis, and visualization in transportation planning and design.
4. Apply GPS-based data collection and positioning techniques for surveying, navigation, and route mapping applications.
5. Analyze geoinformatics-based approaches for transportation planning, traffic management, and decision-making using integrated RS–GIS–GPS tools.

Unit 1: Basics of Geoinformatics and Remote Sensing [4 Hrs]

Introduction to Geoinformatics (RS- GIS-GPS), Fundamental of Remote Sensing History, Type of Remote Sensing, Remote Sensing platforms and sensors, Data acquisition through various platforms, Cameras and sensor parameters.

Unit 2: Satellite Data and Image Analysis [8 Hrs]

Elements of satellite images, Concept of bands, pixel, digital number, metadata, Multispectral Remote Sensing, False color composite, Interpretation of multispectral image, Combination of sensors, Image interpretation parameters, Ground truths.

Unit 3: Digital Image Processing [6 Hrs]

Atmospheric, radiometric, geometric corrections, Histograms, Density slicing, Contrast stretching, Principle component analysis, Basics of digital image processing techniques

Unit 4: Geographic Information Systems (GIS) [8 Hrs]

Introduction to GIS, Components of GIS, Hardware and software, GIS functionality, Data capture, management, analysis and visualization, Projections and georeferencing, Concepts of projections, Types of projections and their applications, Topological data model, TIN, spaghetti, polygon structure data models, Digitization processes

Unit 5: Global Positioning System (GPS) and Applications of Geoinformatics [10 Hrs]

Introduction to GPS, Fundamental concepts, Coordinates and reference systems, Components of GPS system, GPS for land navigation and survey reconnaissance, Static / Differential Positioning, Dynamic / Kinematic Positioning, GPS equipment, National GPS applications. Applications of geoinformatics in transportation engineering.

Unit 6: Self-study Component [6 Hrs]

Case studies on Geoinformatics applications in transportation engineering, Exploration of open-source software (QGIS, Google Earth Engine), Review of recent developments (drones, LiDAR, cloud-based platforms), Study of national initiatives (NRSC, ISRO Bhuvan portals)

Textbooks:

[1] Remote Sensing and Image Interpretation by Thomas M. Lillesand, Ralph W. Kiefer, Jonathan W. Chipman

[2] Geographic Information Systems and Environmental Modeling by Clarke, Keith C., Bradley O. Parks, and Michael P. Crane. Upper Saddle River, NJ: Prentice Hall, 2002.
[3] Principles of Remote Sensing- Edition: ITC Educational Textbook Series 2, Publisher: ITC, nschede Editors: N. Kerle, L.L.F. Janssen, G.C. Huurneman.

Reference Books:

[1] Bhatta, B. (3 Nov 2011). Remote Sensing and GIS (ISBN 019569239X, 9780195692396 ed.). University of Minnesota: Oxford University Press, 2008

	PO1	PO2	PO3	PO4	PO5
CO1	3	1	3	2	2
CO2	3	1	3	2	2
CO3	3	2	3	3	2
CO4	3	2	3	3	2
CO5	3	2	3	3	3

1 – Slightly; 2 – Moderately; 3 – Substantially

SEMESTER II

Analysis and Design of Pavements

Course Code:		**Credit: 4**	
Teaching Scheme: Hrs/Week		**Examination Scheme:**	
Lectures:	3	Theory	Lab
		MSE: 30	ISE: 50
Practical:	2	TA: 20	ESE : 50
Self-Study:	1	ESE: 50	

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

CO 1: Evaluate the behaviour of pavement based on material characteristics.

CO 2: Analyse the pavement by considering various input parameters appropriately.

CO 3: Evaluate and select the rational method of pavement design.

CO 4: Apply the design criteria based on the major failure patterns of pavement.

CO 5: Design the pavement with the guidelines given by IRC, AASHTO, and PCA.

Unit 1 **Introduction** **[8 Hrs]**

Components of pavement structure, importance of sub grade soil properties on pavement performance. Functions of subgrade, subbase, base course and wearing course.

Unit 2 **Stresses in Pavements** **[9 Hrs]**

Flexible pavements - Stresses in homogeneous masses and layered systems, deflections, shear failures, equivalent wheel and axle loads; Rigid pavements - Westergaard's and Thomlinson's analysis of warping stresses, Combination of stresses due to different causes, Effect of temperature variation on Rigid Pavements

Unit 3 **Design Elements of Flexible Pavements** **[9 Hrs]**

Loading characteristics-static, impact and repeated loads, effects of dual wheels and tandem axles, area of contact and tyre pressure, modulus or CBR value of different layers, equivalent single wheel load, equivalent stress and equivalent deflection criterion, equivalent wheel load factors, climatic and environmental factors.

Unit 4 **Design Methods for Flexible Pavements** **[9 Hrs]**

California bearing ratio (CBR) adopted in various countries, IRC: 37-2018, AASHTO Design Guide, Triaxial method, Boussinesq's and Bunnister's analysis, Pavement designing software (IITPAVE, KENPAVE, MICH-PAVE); Design of flexible pavements for low volume roads

Unit 5 **Rigid Pavements** **[13 Hrs]**

Roller Compacted Concrete Pavement, Plain Jointed Concrete Pavement, Continuously Reinforced Concrete Pavement, Prestressed concrete pavement, Design of Tie Bars and Dowel Bars, Role of Dry Lean Concrete; Rigid pavement design for low volume roads,

Design of rigid pavement using IRC: 58-2015 and AASHTO guidelines, Wheel load stresses, Role of modulus of subgrade reaction, Westergaard's analysis, Bradbury's approach Arlington test, Pickett's corner load theory and charts, for liquid, elastic and soil of finite and infinite depths of subgrade.

Unit 6 **Suggested Self-Study Topics (students can choose any 2–3):**

1. **Software-Based Pavement Analysis:** Perform a trial design using IITPAVE, KENPAVE, or any demo version of pavement design software. Interpret critical stresses and deflections.
2. **Comparison of Design Guidelines:** Prepare a comparative table of IRC:37-2018, AASHTO 1993, and Mechanistic-Empirical design guidelines. Highlight differences in traffic, climate, and reliability considerations.
3. **Innovations in Pavement Materials:** Prepare a report on one new material in pavement construction (e.g., Warm Mix Asphalt, Geosynthetics, Steel Slag, or RCC pavements).

4. **Sustainability in Pavement Engineering:** Study carbon footprint reduction techniques in pavement design and construction (recycling, industrial by-products, life-cycle cost analysis).
5. **Future of Pavement Design:** Explore the concept of perpetual pavements or smart pavements (embedded sensors, solar pavements, or self-healing materials).

References

1. Yoder, E.J. and Witczak, M.W., "Principles of Pavement Design 2nd Ed", John Wiley & Songs, Inc. 1975
2. O' Flaherty, A. Coleman, "Highways: the Location, Design, Construction and Maintenance of Road Pavements", 4th Ed., Elsevier 2006
3. Fwa, T.F., "The Handbook of Highway Engineering", CRC Press Taylor & Francies Group. 2006
4. Khanna, S.K. and Justo, C.E.G., "Highway Engineering Nern Chand Jain & Bros, 8th Ed. 2005
5. Papagiannakis, A.T. and Masad, E.A., "Pavement Design and Materials, John Wiley & Sons Inc. 2008
6. Yang H. Huang, " Pavement Analysis and Design" Second Edition, Pearson Education Inc.2004

List of Laboratory Assignments

1. Traffic Loading & ESAL Computation (Design Traffic)
2. Estimate subgrade reaction modulus (k) and resilient modulus (Mr) for use in structural design.
3. Compute critical stresses/strains (surface tensile, vertical compressive at subgrade, subgrade shear) for a proposed multi-layer section under standard axle loads.
4. Design flexible pavement layer thicknesses using an empirical procedure (IRC 37 / AASHTO 1993 empirical approach).
5. Perform structural pavement design (flexible & rigid) for a given traffic and subgrade using standard procedures (AASHTO 1993 / IRC 37 or mechanistic-empirical tools).
6. Design rigid (concrete) pavement slab thickness, joint spacing, and dowel/tie details for given loads and subgrade.

	PO1	PO2	PO3	PO4	PO5
CO1	3	1	3	2	1
CO2	3	1	3	2	1
CO3	3	1	3	2	1
CO4	3	1	3	2	2
CO5	3	2	3	2	2

1 – Slightly; 2 – Moderately; 3 – Substantially

Traffic Flow Modelling and Simulation

Course Code:	**Credit: 3**
Teaching Scheme: Hrs/Week	**Examination Scheme:**
Lectures: 3	MSE: 30
Tutorial:	TA: 20
Self-Study: 1	ESE: 50

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

CO 1: Comprehend, represent and analyze the variation of traffic flow characteristics at microscopic and macroscopic levels using trajectory data

CO 2: Apply the knowledge of various car-following theories for identifying key factors affecting driving behavior and traffic performance

CO 3: Evaluate traffic stability and efficiency for varying roadway and traffic conditions by means of design and control parameters

CO 4: Solve real world transportation problems using queuing theory.

CO 5: Apply programming and simulation skillset to interpret and analyze data pertaining to traffic and transportation engineering problems

Unit 1 Traffic Stream Characteristics [6Hrs]

Measurement of microscopic and macroscopic traffic flow characteristics using loop detectors; Time-space plots; density measurement techniques, gap acceptance behavior. Use of counting, interval and translated distributions for describing Vehicle Arrivals, Headways, driver reaction times, Speeds, Gaps and Lags under varying roadway and traffic conditions. Vehicle- following, lane-changing, lateral and longitudinal vehicular movements under homogeneous and heterogeneous traffic conditions, identifying vehicle- following pairs using vehicular trajectory data numerical simulation of car- following behaviour.

Unit 2 Traffic Stream Models [7 Hrs]

Fundamental Equation of Traffic Flow, continuity equation and its assumptions, Speed-Flow- Concentration Relationships (Fundamental and Macroscopic Fundamental Diagrams), Pedestrian stream models, Normalized Relationship, Fluid Flow Analogy Approach, Gas-kinematic models, Shock- Wave Theory, Car-Following Theory, Advanced Car-Following Models, Psycho-physical models, Traffic Flow Stability, Social-force models, Hysteresis based behavioral studies, two-fluid model, driver behaviour modelling under heterogeneous traffic conditions, Introduction to two- dimensional modelling approach.

Unit 3 Shockwave Analysis [7 Hrs]

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

Unit 4 Queuing Analysis [6 Hrs]

Fundamentals of Queuing Theory, Demand Service Characteristics, Deterministic Queuing Models, Stochastic Queuing Models, Multiple Service Channels, Models of Delay at Intersections and Pedestrian Crossings, Queuing examples and numerical analysis; Determination of number of servers, Average time and vehicles in Queuing system.

Unit 5 Traffic Simulation [6 Hrs]

Monte Carlo method; Generation of Pseudorandom Numbers; Discrete Random deviates; Simulation methods; Fundamentals of simulation, Introduction to factorial experimental designs, Fractional factorial design, Components of traffic simulations models, vehicle arrival and movement models, mixed traffic flow simulation, Simulation model development strategies; Study of large scale simulation models; Scanning Technique; Time based and Even-based methods; Examples of Macroscopic, Mesoscopic, and Microscopic based simulation models, Calibration and Validation of Simulation Models; methodology for calibrating and validating a microscopic traffic simulation model; Case studies of application of simulation for various transportation engineering problems.

Unit 6 **Suggested Self-Study Topics (choose any 2–3):**

1. **Field Data Collection:** Collect short-duration traffic data (volume, headways, or speeds) from a local intersection or roadway. Analyze distributions of arrivals, gaps, or headways using statistical fitting.
2. **Car-Following Simulation:** Use trajectory data (from NGSIM or open datasets) to identify vehicle-following pairs. Simulate one car-following model (e.g., Gipps' model or IDM) and compare with observed behavior.
3. **Shockwave Case Study:** Document one real-life case of congestion due to bottlenecks, incidents, or toll gates. Represent the event using shockwave diagrams on a flow-density plot.
4. **Queue Analysis at an Intersection:** Observe a signalized intersection and apply deterministic/stochastic queuing models to estimate delays. Compare theoretical results with field observations.
5. **Traffic Simulation Project:** Build a simple microscopic simulation in VISSIM, SUMO, or MATLAB (demo versions acceptable). Calibrate the simulation using real or hypothetical data and document results.
6. **Pedestrian Flow Study:** Conduct a study at a pedestrian crossing or corridor. Fit the data into one pedestrian stream model (e.g., social-force model) and report findings.
7. **Emerging Trends:** Prepare a short note on how AI/ML is being used in traffic simulation and driver behavior modelling under heterogeneous traffic.

References

1. Boris S. Kerner, Introduction to Modern Traffic Flow Theory and Control, Spri Edition. Edition, 2009
2. Ni, D., Traffic Flow Theory: Characteristics, experimental methods, and num techniques. Butterworth-Heinemann, 2015
3. Drew, DR., Traffic flow theory and control McGraw Hill Book Company, 1976.
4. Highway Capacity Manual, Transportation Research Board, Washington, D.C., 2016
5. May, A.D. Traffic Flow Fundamentals, Prentice Hall, 1st Edition, 1990.
6. Roger P. Roess, E. S. Prassas and W. R. McShane, Traffic Engineering, Prentice Hall edition, 2010.
7. Clifford S., E. S. Park, Laurence R. R., Transportation Statistic Microsimulation, CRC Press, Taylor and Francis group, 2011.
8. Winnie Daamen, Christine Buisson, Serge P. Hoogendoorn, Traffic Simulation and D Validation Methods and Applications, CRC Press, 2014
9. Edward Chung, Andre-Gilles Dumont, Transport Simulation: Beyond Traditional Ap CRC Press, 2009.

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**1**	**3**	**2**	**1**
CO2	**3**	**1**	**3**	**2**	**1**
CO3	**3**	**1**	**3**	**3**	**1**
CO4	**3**	**1**	**3**	**3**	**1**
CO5	**3**	**2**	**3**	**2**	**2**

1 – Slightly; 2 – Moderately; 3 – Substantially

Highway Structures

Course Code:	**Credit: 3**
Teaching Scheme: Hrs/Week	**Examination Scheme:**
Lectures: 3	MSE: 30
Tutorial:	TA: 20
Self-Study: 1	ESE: 50

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

CO1: **Apply** the principles of hydraulic analysis and soil investigations to determine design flood discharge, linear waterway, and suitable foundations for bridge substructures.
CO2: **Analyze** different types of bridge components (piers, abutments, superstructures) to assess their performance, durability, and maintenance requirements.
CO3: **Evaluate** the suitability of construction methods, foundation types, and protection works for bridges under varying site and load conditions using relevant case studies.
CO4: **Create** bridge inspection and preventive maintenance plans by integrating field observations, quality control aspects, and durability considerations.
CO5: **Design and interpret** structural models of bridge superstructures using software applications (e.g., STAAD.Pro, MIDAS Civil), and **recommend** improvements based on modern materials and intelligent monitoring technologies.

Unit 1 **[7 Hrs]**

Introduction, Investigation for Bridges and Culverts, Investigations for Important Bridges, Design Flood Discharge for bridges, Linear Waterway of Bridges.

Unit 2 **[6 Hrs]**

Choice of Foundation for Piers and Abutments, Types of Bridges and Loading Standards, Setting out for Piers and Abutments, Open Foundation, Pile Foundations, Well Foundation-Case Studies.

Unit 3 **[7 Hrs]**

Piers and Abutments, Superstructure- Design Aspects, Superstructure- Construction, Inspection of Bridges, Maintenance of Bridges- substructure, Maintenance of superstructure – Girders

Unit 4 **[6 Hrs]**

Rebuilding of Bridges, Construction Management, Grade Separators, River Training and Protection Works, Embankments, Tests on Compaction, Approaches, Layers in Flexible and Rigid pavements, Quality Control Aspects

Unit 5 **[6 Hrs]**

Retaining walls, small box culverts, large pipe headwalls, high-mast light poles, ITS devices, reinforced soil slopes, sound abutment walls, overhead signs and traffic signals

Unit 6 Self Study (Any 2-3 of the following)

Safety & ITS Integration: Explore how Intelligent Transportation Systems (ITS) are integrated with bridges for traffic management, monitoring, and safety.
Bridge Investigation Methods – Simple write-up on preliminary and detailed investigations required before bridge construction.
Loading Standards – Prepare a note on IRC Class A, 70R, and Class AA loading, with simple sketches of load arrangements.
Common Foundation Types – Document the differences between open, pile, and well foundations with neat sketches.
Bridge Components – Labelled sketches of substructure (abutments, piers, bearings) and superstructure (deck, girders, slab).

References

1. S. Ponnuswamy, Bridge Engineering, McGraw Hill Education.
2. Das, P.C., 'Management of highway structures', Thomas Telford Publishing, London

	PO1	PO2	PO3	PO4	PO5
CO1	3	1	3	2	1
CO2	3	1	3	2	2
CO3	3	1	3	3	2
CO4	3	2	2	3	2
CO5	3	1	3	2	2

1 – Slightly; 2 – Moderately; 3 – Substantially

PEC II- Sustainable Construction Engineering

Course Code:	**Credit: 3**
Teaching Scheme: Hrs/Week	**Examination Scheme:**
Lectures: 3	MSE: 30
Tutorial:	TA: 20
Self-Study: 1	ESE: 50

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

CO1: Apply principles of sustainability and sustainable development to analyze construction planning within the framework of environment, economy, and ethics.

CO2: Analyze energy, water, and material conservation strategies in buildings and evaluate their effectiveness for sustainable construction.

CO3: Evaluate the suitability of eco-friendly, recyclable, and low embodied energy materials for sustainable construction projects.

CO4: Critically assess and compare green building codes, standards, and rating systems (LEED, IGBC, GRIHA) for their application in sustainable construction practice.

CO5: Design integrated sustainable construction strategies by incorporating green building concepts, energy-efficient technologies, and carbon accounting practice
es.

Unit 1 **[8 Hrs]**

Sustainability and Sustainable Development. Introduction to course. Introduction to sustainable development Concepts and Theory. Definitions and Prospective on sustainability, Theory and background to sustainable construction planning. The Three E's. Environment, Economics, and Ethics. Ecology of sustainable developments.

Unit 2 **[8 Hrs]**

Sustainable Construction Planning. Introduction to Sustainable construction. Principles of sustainability. Major Environmental challenges, Global Warming. Introduction to Green Buildings Building energy system.

Unit 3 **[4 Hrs]**

Strategies, Energy conservation in buildings. Energy Efficient projects. HVAC Systems. Water Conservation in buildings. Rainwater harvesting and management, Water Cycle strategies.

Unit 4 **[8 Hrs]**

Green Buildings Introduction, Green construction, Site selection for Green Construction, Design Considerations, Objectives of Green building movement. Green construction materials and resources. Material Selection Strategies. Eco-friendly Materials, Recyclable and Reusable Materials. Embodied Energy
in Materials.

Unit 5 **[8 Hrs]**

Green Building Codes and Specifications. Introduction. Green building Codes and Standards. LEED Credits, IGBC. International Construction Codes, Carbon accounting, Green building Specifications.

Unit 6 **Self study**

Suggested Self-Study Topics (students can choose any 2–3):

1. Case Study of a Certified Green Building: Document the design features, material choices, and sustainability strategies of one IGBC/LEED-certified building in India.
2. Carbon Footprint Analysis: Perform a simple carbon accounting exercise for a residential or institutional building (use emission factors for materials and energy use).
3. Water & Energy Audit: Conduct a small-scale audit (either in a campus building or using secondary data) for water/energy consumption and suggest conservation measures.
4. Material Sustainability Review: Compare two conventional and two eco-friendly construction materials in terms of embodied energy, recyclability, and lifecycle impact.
5. Policy & Code Comparison: Compare IGBC, GRIHA, and LEED rating systems. Highlight similarities, differences, and applicability in the Indian context.
6. Smart & Sustainable Cities: Prepare a short report on how sustainable urban planning principles are applied in smart city projects in India.
7. Innovation Review: Study one emerging technology in sustainable construction (e.g., 3D-printed concrete, self-healing materials, net-zero buildings, or renewable-integrated systems).

References

1. Green Building Design and Delivery, 2nd Edition, John Wiley, Hoboken -New Jersey.
2. Energy Efficient Buildings in India. Ed. Mujumdar Mili. TERI PRESS.
3. Energy efficient buildings in India. Case Studies by Teri. Video Cassettes, ds.
4. Climate Responsive Architecture. Krishna Arvind.
5. Energy Management Handbook, Steve Doty and Wayne C. Turner, 8th edition.

	PO1	PO2	PO3	PO4	PO5
CO1	3	1	2	2	3
CO2	3	1	2	2	2
CO3	3	1	2	2	2
CO4	2	1	2	2	3
CO5	3	2	2	3	3

1 – Slightly; 2 – Moderately; 3 – Substantially

PEC II- Advanced Optimization Techniques in Engineering

Course Code:	**Credit: 3**
Teaching Scheme: Hrs/Week	**Examination Scheme:**
Lectures: 3	MSE: 30
Tutorial:	TA: 20
Self-Study: 1	ESE: 50

Course Outcomes: At the end of course students will be able to:
CO1: Formulate and solve classical optimization problems, both constrained and unconstrained.
CO2: Develop and apply linear programming models and conduct sensitivity analysis for engineering scenarios.
CO3: Employ integer and dynamic programming techniques for resource allocation and scheduling.
CO4: Design and implement evolutionary algorithms—including genetic algorithms and genetic programming—for optimization tasks.
CO5: Understand and apply fuzzy optimization and heuristic methods to decision-making under uncertainty.

Unit 1: Classical Optimization Techniques [8 Hrs]
Single-variable and multivariable optimization methods, Lagrange multipliers and Kuhn–Tucker conditions, Numerical techniques: Steepest descent and Newton's method, Case examples in mechanical design and manufacturing.

Unit 2: Linear Programming & Sensitivity Analysis [8 Hrs]
LP formulation and graphical solution approach; Simplex and Dual Simplex algorithms; Sensitivity analysis and interpretation of dual variables; Case studies: material allocation and production planning

Unit 3: Integer & Dynamic Programming [8 Hrs]
Integer programming: Branch-and-Bound, Gomory's cutting plane, 0–1 programming; Dynamic programming: multistage decision processes, recursive relations; Applications in project scheduling and resource optimization

Unit 4: Evolutionary Algorithms [8 Hrs]
LP formulation and graphical solution approach; Simplex and Dual Simplex algorithms; Sensitivity analysis and interpretation of dual variables; Case studies: material allocation and production planning

Unit 5: Fuzzy Optimization & Heuristics [8 Hrs]
Fundamentals of fuzzy set theory and membership functions; Fuzzy logic-based optimization frameworks; Heuristic and metaheuristic methods for complex design problems; Decision-making in uncertain and imprecise environments.

Self-Study
MADM; Multi-criteria decision-making techniques (AHP, TOPSIS); Robust optimization and design under uncertainty; Software tutorials: MATLAB Optimization Toolbox, Python (SciPy, DEAP); Development of a mini-project on an optimization topic of choice

Textbooks:

1. S.S. Rao, Engineering Optimization
2. Kalyanmoy Deb, Optimization for Engineering Design
3. D.E. Goldberg, Genetic Algorithms in Search, Optimization, and Machine Learning

Reference Books:

1. F.S. Hillier & G.J. Lieberman, Operations Research
2. Jasbir Arora, Optimal Design
3. Christodoulos A. Floudas, Nonlinear and Integer Optimization

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	2	3
CO2	3	3	3	2	2
CO3	3	2	3	1	3
CO4	3	2	3	2	2
CO5	2	2	3	3	2

1 – Slightly; 2 – Moderately; 3 - Substantially

PEC II- Pavement Construction and Evaluation

Course Code:	**Credit: 3**
Teaching Scheme: Hrs/Week	**Examination Scheme:**
Lectures: 3	MSE: 30
Tutorial:	TA: 20
Self-Study: 1	ESE: 50

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

CO1: Apply MoRTH specifications and equipment knowledge to construct pavement layers with quality control.

CO2: Analyze pavement deterioration and evaluate functional condition using roughness and serviceability measures.

CO3: Evaluate pavement structural performance using NDT methods and suggest overlay or strengthening measures.

CO4: Assess different pavement maintenance techniques and formulate suitable rehabilitation strategies.

CO5: Create sustainable pavement management plans using innovative materials and preventive maintenance approaches.

Unit 1 Highway Construction Equipment [6Hrs]

Applications and safety aspects of earth moving equipment's, compaction equipment's, road making equipment's, concreting equipment's and paving equipments, Hot mix plants, ready mix plants

Unit 2 Pavement Construction [7 Hrs]

Construction and preparation of subgrade, sub-base, base course, construction of bituminous layers, cement concrete surface course as per MoRT&H specifications, Quality control tests during and after construction.

Unit 3 Functional Evaluation of Pavements [7 Hrs]

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

Unit 4 Structural Evaluation of Pavements [6 Hrs]

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

Unit 5 Pavement Maintenance [6 Hrs]

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

Unit 6: Self study

Suggested Self-Study Topics (choose any 2–3):

1. **Case Study on Pavement Failure:** Document one real-life flexible or rigid pavement failure (rutting, potholes, cracking, pumping). Analyze causes and suggest remedial strategies.
2. **Construction Management:** Prepare a sequence plan for constructing a 4-lane flexible pavement section as per MoRTH specifications. Include equipment deployment and quality control steps.
3. **Pavement Roughness Survey:** Collect simple roughness/ride quality data on a nearby road stretch (using Bump Integrator/Smartphone apps). Compare with IRC serviceability standards.
4. **Deflection Study:** Prepare a note on the application of Benkelman Beam Deflection (BBD) or Falling Weight Deflectometer (FWD) in pavement structural evaluation, including one real case.
5. **Innovations in Pavement Materials:** Review the use of recycled materials (plastic waste, fly ash, steel slag, RAP) in pavement construction and their impact on sustainability.
6. **Smart Pavements:** Prepare a short report on sensor-based pavements (e.g., embedded strain gauges, IoT-based monitoring, self-healing asphalt).
7. **Maintenance Planning:** Develop a preventive maintenance plan for a 10-year-old urban road, considering traffic growth, climate, and available budget.

References

1. Croney, D. and P. Croney. The design and performance of road pavements, McGraw-Hill Book Company, London, UK, 1991.
2. Haas, R., W.R. Hudson and J.P. Zaniewski. Modern Pavement Management, Krieger Publishing Company, Malabar, Florida, USA, 1994.
3. Huang, Y.H. Pavement Analysis and Design, Pearson Prentice Hall, New Jersey, USA, 2004.
4. Mallick, R.B. and T. El-Korchi. Pavement Engineering – Principles and Practice, CRC Press, Taylor and Francis Group, Florida, USA, 2009.
5. Ministry of Road Transport and Highways. Specifications for Road and Bridge Works, Fifth Edition, Indian Roads Congress, New Delhi, India, 2013.
6. Papagiannakis, A.T. and E.A. Masad. Pavement Design and Materials, John Wiley and Sons, New Jersey, USA, 2008.
7. Shahin, M.Y. Pavement Management for Airports, Roads, and Parking Lots, Third Edition, Kluwer Academic Publisher, Massachusetts, USA, 2005.
8. Yoder, E.J. and M.W. Witczak. Principles of Pavement Design, Second Edition, John Wiley and Sons, New York, USA, 1975.
9. Relevant IRC Codes.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	1	3	2	1
CO2	3	1	3	1	1
CO3	3	1	3	2	1
CO4	3	2	3	3	2
CO5	3	2	3	3	3

1 – Slightly; 2 – Moderately; 3 – Substantially

PEC II- Rail and Metro Construction

Course Code:	**Credit: 3**
Teaching Scheme: Hrs/Week	**Examination Scheme:**
Lectures: 3	MSE: 30
Tutorial:	TA: 20
Self-Study: 1	ESE: 50

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

CO1: Apply knowledge of railway origins, gauges, and track structures to analyze maintenance and renewal practices.

CO2: Analyze the design and operation of turnouts, crossings, and curved tracks to ensure safe and efficient train movement.

CO3: Evaluate passenger and goods rolling stock with reference to development, classification, and maintenance standards.

CO4: Assess rail–wheel interaction and the performance of different track elements and sleeper types.

CO5: Create planning and management strategies for metro rail systems including construction, operations, depots, and passenger services.

Unit 1 **[6Hrs]**

Origin of Railways, Definition/uniqueness of railways, gauge of railway track, over view of railway systems of different countries, Basic track structure Formation, unconventional railways, atmospheric railway, mountain railways, rack railways etc. Basic track structure – Formation, Maintenance and renewal of track – (in brief) manual and mechanical maintenance and renewal.

Unit 2 **[7 Hrs]**

Turnouts and Crossings – Components constituting turnouts and crossings, Diamond crossings; Slip points, operation of turnouts mechanical & electrical, locking of turnouts, Curved Track – classification of curves, measurement of radius, movement of vehicle on curves, speed on curves, check rails, gauge widening on curves. Gradients / Vertical Curves.

Unit 3 **[7 Hrs]**

Passenger carrying vehicles (Coaches), development of coaches, 4 wheeled coaches, 6 wheeled coaches, bogie coaches, categories of coaches, Pullman coaches, special coaches in very brief, Goods carrying vehicles, Introduction of maintenance manuals of various types of rolling stock.

Unit 4 **[6 Hrs]**

Rail Wheel Interaction, Track elements, Flat Bottom Rail, Bull Head Rail, Cast Iron Chair, Rail Screws, Base Plate, Insulating Pad, Modified Loose Jaw, Fish Plated Joint, Insulated Joint Sleepers - Wooden, Steel Trough, Cast Iron Pot, Twin Block and Mono Block Pre-Stressed Concrete Sleepers.

Unit 5 **[6 Hrs]**

Origin of Metro Rail System, Overview of World Metro Systems, Metro Planning and Selection, Metro Construction Metro Track, Introduction of metro act, Report of Ministry of Urban Development on standardization of metro system. Metro Operations, Metro Depots, Metro Maintenance, Metro Station Management, Passenger Information System.

Unit 6 **Self study**

Suggested Self-Study Topics (choose any 2–3):

1. **Case Study of Railway Development:** Document the evolution of Indian Railways compared with any one international railway system (e.g., Japan Shinkansen, European HSR). Highlight technological and operational differences.
2. **Turnout Operation Study:** Prepare a note on the working of modern turnout mechanisms (hydraulic/electrical). Compare with conventional mechanical systems.
3. **Rolling Stock Case Study:** Collect details of one type of modern coach or wagon (e.g., LHB coaches, double-stack containers). Summarize design features, safety, and operational advantages.
4. **Track Renewal and Maintenance:** Review a case of large-scale railway track renewal in India (manual vs. machine-based). Discuss advantages, challenges, and mechanization benefits.
5. **Metro Planning Study:** Select one Indian metro project (Delhi, Bengaluru, Hyderabad, or Mumbai). Prepare a report covering planning, construction challenges, financing, and operational outcomes.
6. **Rail–Wheel Interaction:** Collect information on derailments in Indian Railways due to rail–wheel issues. Analyze causes and preventive measures.
7. **Smart Metro Systems:** Prepare a short note on intelligent passenger information systems and smart ticketing technologies in modern metros.

References

1. Indian Railways Permanent Way Manual Published by Indian Railways corrected upto ACS-4, June 2020.
2. Notes on Curves for Railways by Prof V B Sood _ Indian Railways Institute of Civil Engineering Pune.
3. Ponnuswamy, Bridge Engineering, Delhi.
4. Metro Act _ Government of India – 2002
5. Detailed Project Reports of Various Metro Projects in India – By Delhi Metro Rail Corporation.
6. Manual of Specifications and Standards – Hyderabad Metro Government of Andhra

	PO1	PO2	PO3	PO4	PO5
CO1	3	1	3	2	1
CO2	3	1	3	2	1
CO3	3	1	3	2	1
CO4	3	1	3	2	1
CO5	3	2	3	3	2

1 – Slightly; 2 – Moderately; 3 – Substantially

PEC II- Freight Transportation Planning and Logistics

Course Code:	**Credit: 3**
Teaching Scheme: Hrs/Week	**Examination Scheme:**
Lectures: 3	MSE: 30
Tutorial:	TA: 20
Self-Study: 1	ESE: 50

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

CO1: *Explain* freight demand modeling approaches, including gravity, input-output, and spatial equilibrium models, along with freight generation concepts.

CO2: *Apply* network flow algorithms such as shortest path, assignment, and transportation problem techniques for freight movement optimization.

CO3: *Analyze* micro-level distribution structures, logistics costs, warehouse location models, and inventory-based freight transport strategies.

CO4: *Evaluate* urban freight models, vehicle routing, fleet optimization, and humanitarian logistics solutions for efficient and resilient operations.

CO5: *Assess and critique* emerging trends in digitalization, sustainability, policy frameworks, and innovative practices in freight transportation through case studies.

Unit 1 Introduction to freight models; interregional freight demand models [8 Hrs]

Gravity model, Input output (IO) model, Spatial general equilibrium model (SGEM); Freight generation and freight trip generation models.

Unit 2 Introduction to network flow [8 Hrs]

Network flow representation, shortest path algorithm, Assignment Problem, Transportation Problem, Minimum spanning tree, Minimum cost network flow problem, Network simplex method;

Unit 3 Distribution structure [8 Hrs]

Micro-level distribution structure, Logistics costs, Drivers of distribution structure, Micro-level normative models, Warehouse location; Inventory theory and freight transport modeling: the economic order quantity (EQQ) model, Optimal shipment size.

Unit 4 Urban freight models [8 Hrs]

Push models, Pull models; Vehicle routing problem; Fleet size optimization; Urban logistics: parcel delivery, e-commerce, food delivery; Freight consolidation centers; Humanitarian logistics during disasters.

Unit 5 Self-Study Component

Emerging Trends and Case Studies in Freight Transportation

1. **Digitalization in Freight Transport** – Role of Big Data, Artificial Intelligence, and Machine Learning in freight demand forecasting, dynamic routing, and real-time shipment tracking.
2. **Sustainable Freight Systems** – Green logistics, decarbonization strategies in freight transport, modal shift to rail/waterways, and use of electric/hydrogen freight vehicles.
3. **Freight Corridors and Policy Frameworks** – Case study of **Dedicated Freight Corridors (India)** and **European TEN-T Freight Network**; policy support for freight integration.
4. **Urban Freight Innovations** – Crowdshipping, use of drones and autonomous

vehicles, micro-hubs for last-mile delivery.

5. **Case Study Approach** – Review of selected national and international freight transport systems (e.g., Amazon, DHL, Indian Railways freight business, e-commerce logistics).

References

1. L. Tavasszy and G. De Jong, Modeling Freight Tranport, Elsevier, 2014
2. M. Browne, S. Behrends, Woxenius, G. Giuiano, and J, Holguin-Veras, Urban Logistics, Kogan Page, 2019
3. E. Taniguchi and R. G. Thompson, City Logistics, Emerald Group Publishing, Limited, 2001

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	1	3	2	1
CO2	3	1	3	3	1
CO3	3	2	3	3	1
CO4	3	2	3	3	2
CO5	2	2	2	2	3

1 – Slightly; 2 – Moderately; 3 – Substantially

PEC II -Intelligent Transportation Systems

Course Code:	**Credit: 3**
Teaching Scheme: Hrs/Week	**Examination Scheme:**
Lectures: 3	MSE: 30
Tutorial:	TA: 20
Self-Study: 1	ESE: 50

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

CO1: Apply ITS objectives and data collection techniques to analyze transportation system performance.

CO2: Analyze the role of telecommunications and traffic management centers in vehicle–roadside communication and positioning.

CO3: Evaluate different ITS functional areas such as ATMS, ATIS, CVO, AVCS, and APTS for improving transport efficiency and safety.

CO4: Assess user needs and ITS services for traffic, transit, safety, payment, and emergency management.

CO5: Create strategies for automated highway systems and emerging ITS applications including smart cities, CAVs, and sustainable mobility.

Unit 1 **Introduction to Intelligent Transportation Systems (ITS)** **[6 Hrs]**

Definition of ITS and Identification of ITS Objectives, Historical Background, Benefits of ITS - ITS Data collection techniques – Detectors, Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), Geographic
Information Systems (GIS), video data collection.

Unit 2 **Telecommunications in ITS** **[7 Hrs]**

Importance of telecommunications in the ITS system, Information Management, Traffic Management Centres (TMC). Vehicle – Roadside communication – Vehicle Positioning System

Unit 3 **ITS functional areas** **[7 Hrs]**

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).

Unit 4 **ITS User Needs and Services** **[6 Hrs]**

Travel and Traffic management, Public Transportation Management, Electronic Payment, Commercial Vehicle Operations, Emergency Management, Advanced Vehicle safety systems, Information Management.

Unit 5 **Automated Highway Systems** **[6 Hrs]**

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

Unit 6 **Self-Study Component (Any 2-3)**

Emerging Trends and Case Studies in ITS

1. **Smart Cities and ITS** – Role of ITS in smart mobility, integration with IoT, cloud computing, and AI for traffic management.
2. **Connected and Autonomous Vehicles (CAVs)** – V2V (Vehicle-to-Vehicle), V2I (Vehicle-to-Infrastructure), V2X communications, safety applications, and ethical challenges.
3. **Sustainable ITS Applications** – ITS for reducing emissions, eco-driving support systems, integration with EV charging infrastructure, multimodal transport optimization.

4. **Cybersecurity in ITS** – Risks in vehicle communication systems, data privacy issues, security strategies.
5. **Case Studies** –
    - **India:** FASTag and Electronic Toll Collection, Bangalore traffic management through ITS, Delhi metro smart card system.
    - **Global:** Japan's VICS, Singapore's ERP, U.S. Connected Vehicle Pilot Programs.

References

1. Pradip Kumar Sarkar and Amit Kumar Jain; Intelligent Transportation Systems' PHI Learning, 2018
2. Mashrur Chowdhury and Adel W. Sadek, Fundamentals of Intelligent Transportation Systems Planning, Artech House Publishers, 2003
3. Relevant IRC codes, publisher IRC

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	1	3	2	1
CO2	3	1	3	3	1
CO3	3	2	3	3	2
CO4	2	2	2	3	2
CO5	2	2	3	3	3

1 – Slightly; 2 – Moderately; 3 – Substantially

PEC III -Applications of AI ML in Transportation Engineering

Course Code:	**Credit: 3**
Teaching Scheme: Hrs/Week	**Examination Scheme:**
Lectures: 3	MSE: 30
Tutorial:	TA: 20
Self-Study: 1	ESE: 50

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

CO 1: Define data mining concepts and data pre-processing techniques

CO 2: Analyze components of Instance-Based Learning, explaining KNN and variants

CO 3: Implement Decision Tree construction and Support Vector Machines, with a focus on multiclass classification

CO 4: Assess Outlier Mining techniques, differentiating between statistic-based, distance-based, and density-based methods

CO 5: Design Ensemble Learning methods (Bagging, Boosting, etc.) and propose strategies for handling class-imbalanced data

Unit 1 **Introduction to data mining and pre-processing** **[13 Hrs]**

What is data mining, Data mining functionality, Data Mining Techniques, Techniques of preprocessing data, including data cleansing, Data integration, data reduction, and transformation.

Unit 2 **Instance based learning** **[7 Hrs]**

Overview of IBL, three components of KNN and two Variants of kNN

Unit 3 **Decision trees and Support vector machine** **[6 Hrs]**

Decision tree representation, Construct Decision Tree, Overfitting and Tree Pruning, Pros and Cons of DTs, Decision Tree Representation

Linear Support Vector Machine and non-Linear Support Vector Machine, multiclass classification, support vector regression.

Unit 4 **Outlier mining** **[6 Hrs]**

Background of Outlier Detection**,** three techniques to detect outliers, including statistic-based method, distance-based method, and density-based method.

Unit 5 **Ensemble leaning** **[6 Hrs]**

General Idea of Ensemble Methods, several classical ensemble methods, including Bagging, boosting, Cross validated Committees, and random forests. Generation of members and combining schemes in general. Besides, techniques to improve the classification performance for class-imbalanced
data.

Unit 6 **Self-Study Component (Any 2-3)**

Advanced Topics and Applications in Data Mining

1. **Feature Selection and Dimensionality Reduction** – PCA, t-SNE, LDA and their role in improving model performance.
2. **Deep Learning for Data Mining** – Introduction to neural networks, CNNs, RNNs for pattern recognition.
3. **Text Mining and Natural Language Processing (NLP)** – Techniques for text classification, sentiment analysis, and topic modeling.
4. **Time Series and Sequential Pattern Mining** – Mining sequential data, applications in finance, IoT, and transportation.
5. **Big Data and Data Mining** – Use of Hadoop, Spark, and distributed computing for large-scale data analysis.

6. **Case Studies** –
    - Fraud detection in banking/insurance
    - Recommendation systems (e.g., Netflix, Amazon)
    - Predictive maintenance in engineering

References

1. Jiawei Han, Micheline Kamber and Jian Pei, Data Mining: Concepts and Techniques, Morgan Kaufmann, 3rd edition, 2011.
2. Ian H.Witten, Eibe Frank, Data Mining: Practical Machine Learning Tools and Techniques with Java Implementations, San Francisco: Morgan Kaufmann Publishers, 3rd ed. 2011.
3. Charu C. Aggarwal, Data Mining: The Textbook, Springer, May 2015.
4. Pang-Ning Tan, Michael Steinbach, Vipin Kumar, Introduction to Data Mining, Pearson, 1st Edition, 2005.
5. Christopher M. Bishop, Pattern recognition and machine learning, the Morgan Kaufmann series in information science and statistics, Springer Science, 2006.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	1	2	1	1
CO2	3	1	3	1	1
CO3	3	2	3	2	1
CO4	3	2	2	2	1
CO5	3	2	3	2	2

1 – Slightly; 2 – Moderately; 3 – Substantially

PEC III -Road Safety and Road Safety Audit

Course Code:	**Credit: 3**
Teaching Scheme: Hrs/Week	**Examination Scheme:**
Lectures: 3	MSE: 30
Tutorial:	TA: 20
Self-Study: 1	ESE: 50

Course Outcomes: Students will be able to:

1. Define key aspects of road accidents, distinguish accidents from crashes, and recall elements of road safety plans.
2. Explain the impact of human factors on road safety, analyze planning considerations, and comprehend crash reconstruction principles and statistical analysis of accidents.
3. Utilize road safety engineering principles for designing safe road links and junctions, apply statistical analysis to predict accidents, and use crash data for hazard identification.
4. Evaluate economic aspects of accidents, analyze road safety audits, and critically assess crash locations through diagnostic processes and data interpretation.
5. Assess the effectiveness of road safety strategies, before-after methods in crash analysis, and critically evaluate statistical models related to accidents and road safety audits.

Unit 1: Introduction [7 Hrs]

Road traffic accidents scenario in India, characteristics of accidents, accident vs. crash, effect of human factors, planning for road network, land use and road environment for safety, designing for road safety - links and junctions, road safety engineering, road safety improvement strategies, elements of a road safety plan.

Unit 2: Crash investigation and analysis [9 Hrs]

Steps in treatment of crash locations, diagnosing crash problem and solutions, accident report form, storing of data, using and interpreting crash data, identifying and prioritizing hazardous locations, condition and collision diagrams; Vulnerable Road Users: crashes related to pedestrian and bicyclists, their safety, provision for disabled; Crash reconstruction: understanding basic physics, calculation of speed for various skid, friction, drag, and acceleration scenarios

Unit 3: Statistical analysis of accidents [7Hrs]

Descriptive statistics, confidence interval, hypothesis testing, models related to accident frequency, accident severity, accident duration, various methodological issues - over/under dispersion, time-varying explanatory variables, unobserved heterogeneity, endogeneity, under-reporting, spatial and temporal correlation, etc; Accident prediction model.

Unit 4: Before -after methods in crash analysis [6Hrs]

Before and after study, before and after study with control sites, comparative parallel study, before, during and after study, Empirical Bayes method

Unit 5: Economic analysis of accidents [6Hrs]

Introduction to Economic Analysis of Accidents, Components of Accident Costs, Accident costing-economic appraisal, Methods of accident costing, Economic Appraisal of Road Safety Projects, EUAC, PWOC, B/C ratio, IRR, NPV.

Unit 6: Self-Study

National and international standards for road safety (IRC, MoRTH, AASHTO, PIARC guidelines), Legal and institutional aspects of road safety in India, Road safety action plans and policies (state and national level), Road safety education, enforcement, and awareness programs, Emerging technologies in road safety (AI-based video analytics, drones for safety monitoring).

Textbooks:

[1] R.S. Jacob & Dr. K. Ramachandran, Road Safety Engineering, PHI Learning (2018)

[2] Dr. S.K. Khanna, C.E.G. Justo & A. Veeraragavan, Highway Safety and Accident Analysis, Nem Chand Publishers

[3] Rune Elvik, Alena Høye, Truls Vaa, Michael Sørensen, Highway Safety Engineering, Cengage Learning, Latest Edition

[4] Roger P. Roess, Elena S. Prassas, William R. McShane, Traffic Engineering. Pearson Education, 5th Edition

[5] Simon Washington, Matthew Karlaftis, Fred Mannering, Transportation Statistics and Microsimulation, CRC Press, 2nd Edition

Reference Books:

[1] PIARC (World Road Association) – *Technical Reports on Road Safety & AI Applications*; International Best Practices

[2] IRC: SP: 88 – *Manual on Road Safety Audit: Road Safety Audit Guidelines (India)*

[3] IRC: SP: 84, IRC: 35, IRC: 67: Road Accident Investigation

[4] MoRTH – *Road Accident Report Annual Publications: Crash Data & Institutional Aspects*

Web Resources:

[1] National Highways Authority of India "Manual on Road Safety Audit" (PDF) — provides procedure, stages of audit (feasibility, design, construction, operational) and India-context details.

[2] Urban-Road Safety Audit guideline (PDF) — focused on urban contexts: land-use, pedestrian/bicycle vulnerable users etc.

[3] "RSA of Roads more than 5 KM in length" – Government of India portal (NRIDA/PMGSY) — audit requirement for rural roads, good for link with planning, land-use, safety elements.

[4] "Road Safety Audit Guidelines of Selected Nations — comparative review" (journal article) — helpful for self-study of international vs Indian standards, institutional/legal aspects.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	2	1	2	1	1
CO2	3	2	3	2	2
CO3	3	2	3	2	3
CO4	3	3	3	2	3
CO5	3	3	3	3	3

1 – Slightly; 2 – Moderately; 3 - Substantially

PEC III -Sustainable Transportation

Course Code:	**Credit: 3**
Teaching Scheme: Hrs/Week	**Examination Scheme:**
Lectures: 3	MSE: 30
Tutorial:	TA: 20
Self-Study: 1	ESE: 50

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

CO1: Apply sustainability concepts to analyze transport-related issues such as energy use, emissions, congestion, and urban form.

CO2: Analyze pedestrian and cycling demand, safety, and conditions to prioritize facility improvements.

CO3: Evaluate pedestrian and bicycle planning, design, and integration strategies for safe and sustainable mobility.

CO4: Assess sustainable transport policies, pricing mechanisms, and travel demand management approaches.

CO5: Create sustainable mobility strategies using cleaner technologies, ITS, and non-motorized and public transport solutions.

Unit 1 **Problem of Sustainability in Transport and Planning for Sustainability** **[12 Hrs]**

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

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

Unit 2 **Evaluation of Non-Motorized Transportation** **[6 Hrs]**

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

Unit 3 **Planning for Pedestrians and Bicyclists** **[12 Hrs]**

Pedestrians: Types of pedestrians and Characteristics; Pedestrian facilities and planning; Pedestrian standards and improvements; Pedestrian facility Design, LOS; Pedestrian safety programs, **Bicyclists:** Types of cyclists and Bikeways; Integrating cycling into roadway planning; Bicycle network planning; Accommodating cyclists on rural roads; Design of Bicycle boulevards/bike paths; Bicycle Parking/storage Facilities; Roadway maintenance for cyclists.

Unit 4 **Sustainable Policies** **[6 Hrs]**

Continuum of Policies, Speed and Speed Limit Policies, National policies, sustainable travel demand management; public awareness; pricing transportation: full cost of transportation, pricing and taxation.

Unit 5 **Sustainable Technology and Nationally Appropriate Mitigation Actions** **[12 Hrs]**

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

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

Unit 6 **Self-Study Component**

1. **Global Case Studies in Sustainable Transport**
   - Copenhagen cycling policies, Bogotá BRT system, Singapore congestion pricing, London Ultra Low Emission Zone.
2. **Emerging Mobility Concepts**
   - Shared mobility (carpooling, bike-sharing, e-scooters).
   - Mobility-as-a-Service (MaaS).
3. **Sustainability Assessment Tools**

- Life Cycle Assessment (LCA) in transport projects.
- Sustainable Urban Mobility Indicators (SUMI).

4. **Equity and Accessibility Issues**
   - Transport solutions for vulnerable groups (elderly, disabled, low-income).
   - Gender-sensitive mobility planning.
5. **Indian Context**
   - Smart City Mission and its transport sustainability focus.
   - Metro rail systems and their role in reducing emissions.
   - Electric vehicle adoption policies in India.

References

1. Black, W. R., Sustainable Transport: Definitions and Responses, In 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. 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.
4. Mehrdad Ehsani, Fei-Yue Wang and Gary L. Brosch (Eds.) Transportation technologies for sustainability, 2013.
5. Preston L. Schiller, Eric C. Brunn and Jeffrey R. Kenworthy. An Introduction to Sustainable Transportation: Policy, Planning and Implementation, 2010.
6. Rodney Tolley, Editor, Sustainable Transport: Planning for walking and cycling in urban environments; CRC Press, 2003.
7. Tolley, R., Sustainable Transport: Planning for Walking and Cycling in Urban Environments, CRC Press, 2003.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	1	3	2	3
CO2	3	1	2	3	2
CO3	3	1	3	3	2
CO4	2	2	3	3	3
CO5	3	2	3	3	3

1 – Slightly; 2 – Moderately; 3 – Substantially

PEC III -Underground openings

Course Code:	**Credit: 3**
Teaching Scheme: Hrs/Week	**Examination Scheme:**
Lectures: 3	MSE: 30
Tutorial:	TA: 20
Self-Study: 1	ESE: 50

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

CO1: Apply codal provisions, design methodologies, and functional requirements to determine the geometry and support systems of underground openings.

CO2: Analyze stresses around different tunnel shapes and evaluate stability using analytical, empirical, and numerical methods (RSR, RMR, Q-system, FEM, NATM).

CO3: Evaluate the suitability of excavation methods and tunnelling machinery (blasting, TBM, bottom-up/down methods) in different ground conditions with safety considerations.

CO4: Design appropriate tunnel support systems and assess ground response, surface settlement, and instrumentation monitoring results.

CO5: Formulate sustainable strategies for tunnel health, safety, and rehabilitation by integrating case studies, fire safety, ventilation systems, and modern monitoring technologies.

Unit 1 Introduction [6 Hrs]

Introduction to underground space and tunnelling, History, Tunnelling challenges, Types and classification of underground opening, Factors affecting design, Design methodology, Functional aspects, Size and shapes, Support systems, Codal provisions

Unit 2 Excavation Method and Machinery [6 Hrs]

Drilling and Blasting for Underground and Open Excavations. Tunnel driving techniques, TBM techniques, Bottom up and bottom down method, Tunnelling in difficult ground condition, Underground supports, theory of arching, rock loads and loads on tunnel linings, Safety aspects, Case histories.

Unit 3 Analysis And Design of Underground Openings [6 Hrs]

Analysis of Underground openings, stresses around different shapes, initial state of stresses, Closed form solutions, FEM, Design based on analytical methods, Empirical methods based on RSR, RMR, Q systems, Observational method- NATM, Convergence-confinement method, Design based on Wedge failure and key block analysis, Design of Shafts and hydraulic tunnels.

Unit 4 Design of Support System [6 Hrs]

Tunnel support systems, Different type of supports, Standup time, Ground Reaction Curve, Stability of excavation face and Tunnel portals, Surface settlement due to underground works, Ground subsidence study, Use of appropriate software packages, Shotcreting including some case histories, Underground instrumentation and monitoring

Unit 5 Tunnel Health and Safety Issues [6 Hrs]

Construction methods, Ventilation, De-watering, Control and monitoring system: services, operations and maintenance. Surveillance and control system for highway tunnels. Tunnel finish, Rehabilitation: Inspection methods, Repairs, Tunnel construction contracting.

Unit 6 Self study

Collect case histories of 2–3 tunnels in India, summarise their design challenges and solutions. Compare circular vs horseshoe vs elliptical tunnel sections and why each is adopted. Prepare a short note on India's TBM usage in metros Study one case of a tunnelling accident due to a blasting mishap and note preventive measures. Use a simple FEM software (e.g., PLAXIS demo version) for a basic stress analysis around a circular tunnel. Collect at least one failure case study of a tunnel (collapse, excessive settlement, or leakage). Document a case study of ground settlement in urban tunnelling. Prepare a fire safety strategy for a metro tunnel. Compare the ventilation systems used in highway vs metro tunnels.

References

1. Ramamurthy T., "Engineering in Rocks for Slopes, Foundation and tunnels", Prentice Hall of India Pvt Ltd, New Delhi, 2010.
2. Kolymbas, D., "Tunneling and tunnel mechanics: A rational approach to tunnelling", Springer Publications. 2008.
3. Goodman, R. E., "Introduction to Rock Mechanics", John Wiley & Sons, 1989.
4. Hoek, E. and Brown, E. T., "Underground excavations in rock", The Institute of mining and metallurgy. 2005.
5. Brady, B. H. G. and Brown, E. T., "Rock mechanics for underground mining", Springer Publication, 2006.
6. Obert, L. and Duvall, W.I., "Rock mechanics and the design of structures in rock", John Wiley and Sons, 1967.
7. Chapman D, Metje, N and Stark A, "Introduction to tunnel construction", Spon Press, Taylor and Francis, 2010.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	1	3	2	1
CO2	3	1	3	2	1
CO3	3	1	3	3	2
CO4	3	2	3	3	2
CO5	2	2	2	3	3

1 – Slightly; 2 – Moderately; 3 – Substantially

PEC III -Public Transportation Planning

Course Code:	**Credit: 3**
Teaching Scheme: Hrs/Week	**Examination Scheme:**
Lectures: 3	MSE: 30
Tutorial:	TA: 20
Self-Study: 1	ESE: 50

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

CO1: **Analyze** operational characteristics of various transit modes and determine factors influencing transit demand estimation.

CO2: **Design** transit routes, networks, and service coverage plans considering operational and user requirements.

CO3: **Develop** bus and rail scheduling models including fleet requirements, stop spacing, and depot locations using optimization techniques.

CO4: **Evaluate** corridor alternatives, system selection, and terminal designs based on capacity, performance, cost, and user experience.

CO5: **Propose** sustainable, equitable, and technologically advanced strategies for improving transit systems in urban contexts.

Unit 1 **Transit Systems, Estimation of Transit Demand** **[12 Hrs]**

Growth history – Urban growth & transit evolution - Types of Transit Modes - Buses - LRT, RTS- Para Transit - Dial - a- Ride-Taxi- Jitney and Ridesharing – Operational characteristics speed, capacity & payloads – Selection criteria for transit systems.

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

Unit 2 **Transit Design and Route Network Planning** **[12 Hrs]**

Frequency & headway determination methods – Rail operation design – Bus operation design – Way capacity & Station capacity –Transit level of service.

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

Unit 3 **Scheduling** **[6 Hrs]**

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

Unit 4 **Mass Transit Corridor Identification & Planning** **[6 Hrs]**

Corridor identification - Network Compression Method - Planning of Rapid Transit System - System Selection - Aesthetics and Noise Consideration - Cost of Construction - Station Arrangements - Platform Capacity - Fare Structure, Transit Marketing.

Unit 5 **Transit Terminals and Performance Evaluation** **[6 Hrs]**

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

Unit 6 Self-study content (Any 2-3)

1. Global Best Practices in Transit Systems

1. Compare the planning and operational strategies of BRT systems in Bogotá and Ahmedabad.
2. Discuss how multimodal integration in Singapore has improved commuter convenience.

2. Emerging Technologies in Public Transit

1. Evaluate the challenges and opportunities of adopting electric buses in Indian cities.
2. How can real-time passenger information systems enhance transit reliability and user satisfaction?

3. Sustainability and Equity in Transit Planning

1. Explain the importance of accessibility planning in creating inclusive public transportation.
2. Assess the role of gender-sensitive planning in improving safety and ridership in transit systems.

4. Transit-Oriented Development (TOD) and Land Use Integration

1. Discuss the benefits and limitations of implementing TOD around metro corridors in Indian cities.
2. How does mixed-use development around transit nodes contribute to reducing car dependency?

5. Innovations in Performance Assessment

1. How can big data analytics improve transit demand forecasting and operational efficiency?
2. Suggest a framework for benchmarking service quality of urban transit systems using international indicators.

References

1. Black, Alan, Urban Mass Transportation Planning, McGraw- Hill,Inc., New York,1995.
2. Ceder, A.,Public Transit Planning and Operation: Theory, Modeling and Practice, B-H Elsevier Ltd., MA, 2007.
3. David A. Hensher, Bus Transport: Economics, Policy and Planning. Research in Transportation Economics Volume 18. Elsevier Publications, 2007.
4. G.E. Gray and CA Hoel: Public Transport Planning Operation and Management, Prentice Hall; 2nd Edition, 1992
5. Khisty C J., LallB.Kent, Transportation Engineering – An Introduction, Prentice- Hall, NJ, 2005
6. Papacostas C.S. and Prevedouros, P.D., Transportation Engineering & Planning, PHI, New Delhi,2002
7. Vukan, R. Vuchic, Urban Public Transportation: Systems & Technology, John – Wiley & Sons, New Jersey, 2007.
8. Vukan, R. Vuchic, Urban Transit: Operations, Planning and Economics, John – Wiley & Sons, New Jersey, 2005.
9. Vukan,R.Vuchic et. al, Timed Transfer System Planning, Design and Operation: Final Report, The Program,1983.
10. Sarkar P., Maitry V., Joshi G.J., Transportation Planning – Principles, Practices &Policies,PHI,New Delhi (2014)
11. Simpson, Barry J., Urban Public Transport Today. Taylor & Francis Routledge Publisher, 2003

12. Tiwari G., Urban Transport for Growing Cities – High Capacity Bus System, MacMillan India Ltd., 2002
13. Tyler N., Accessibility and the Bus System – Concepts and Practice, Thomas Telford, 2002.
14. Transit Capacity and Quality of Service Manual, Third Edition, Transit Cooperative Research Program (TCRP) Report 165: Transport Research Board, 2013.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	2	3	2	1
CO2	**3**	1	3	3	1
CO3	**3**	2	3	3	1
CO4	**3**	2	3	3	1
CO5	**2**	2	2	3	3

1 – Slightly; 2 – Moderately; 3 – Substantially

PEC III -Highway Financing and Policy Analysis

Course Code:	**Credit: 3**
Teaching Scheme: Hrs/Week	**Examination Scheme:**
Lectures: 3	MSE: 30
Tutorial:	TA: 20
Self-Study: 1	ESE: 50

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

CO1: Apply concepts of economic theory to analyze the relationship between transportation, economic growth, and urban development.

CO2: Analyze cost structures, pricing strategies, and subsidy policies to evaluate efficiency and equity in transportation systems.

CO3: Evaluate transport demand, supply, and congestion management measures using forecasting methods, elasticity concepts, and congestion pricing principles.

CO4: Critically assess regulatory frameworks, fiscal measures, and equity considerations in formulating sustainable transportation policies.

CO5: Design project evaluation and financing strategies using economic appraisal tools (IRR, cost–benefit analysis, multi-criteria decision methods) and innovative funding mechanisms (PPP, bonds, green financing).

Unit 1 **Introduction to Transportation Economics and Economic Theory [5hrs]**

Scope of Transportation Economics, Relationship between transport, economic development and urban development, Economic theory basics: demand and supply in transportation, demand–supply equilibrium, Law of diminishing returns, Elasticity and consumer surplus

Unit 2 **Costs, Pricing and Subsidies in Transportation [7 hrs]**

Cost structures: direct and external costs, generalized costs, social aspects of transport, Joint and common costs of infrastructure, Average and marginal cost principles, Short-term and long-term costs of supply, Road user cost and its components, Pricing principles: efficient pricing, cost complexities, cost recovery, Peak load pricing, second-best pricing, Subsidy policies, transport subsidies and price discrimination.

Unit 3 **Demand, Supply and Congestion in Transport Sector [6 hrs]**

Demand forecasting methods, Price elasticity of demand, Causes of traffic congestion, Congestion pricing, road space rationing, capacity expansion, Supply of transport services and systems supply function

Unit 4 **Regulation, Equity and Policy Measures [5 hrs]**

Command and control type of regulation, Fiscal measures: road pricing, environmental taxation, Safety and economic regulations in public transport services, Issues of social, geographical and temporal equity

Unit 5 **Project Evaluation and Financing of the Transportation Systems [6 hrs]**

Evaluation of alternatives and analysis techniques, Social and financial benefits, Internal Rate of Return method for economic and financial viability, Valuation of time, measures of land value, consumer benefits from projects, Prioritization of projects, multi-criteria decision assessment, Construction of new infrastructure: investment analysis, Methods for raising funds: taxation, user fees, loans, bonds, PPPs/PSPs, concessions

Unit 6 Self-Study Component (Any 2-3)

Case Studies in Transportation Economics

- Urban congestion management (e.g., Singapore, London congestion pricing)
- Public transport subsidy models in developing vs developed countries

Sustainable Transportation Economics

- Externalities: environmental costs of transport and carbon pricing
- Green financing and climate-friendly infrastructure investments

Advanced Demand and Cost Issues

- Induced demand and rebound effects
- Value of reliability and travel time savings in project appraisal

Innovative Financing Mechanisms

- Toll roads and expressways in India (case-based analysis)
- Role of PPP models in highway/metro projects

Digital and Smart Mobility Economics

- Economic implications of ride-hailing services (Uber, Ola, etc.)
- Impact of Intelligent Transport Systems (ITS) and e-mobility on cost recovery

References

1. Mccarthy, P.S., "Transportation Economics- Theory and Practice: A Case Study Approach", Blackwell Publishing
2. E. Quinet, R. Vickerman and R.W. Vickerman, "Principles of Transport Economics", Edward Elgare Publishing.
3. Button, K.J., "Transportation Economics", 3rd Ed., Edward Elgare Publishing

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	1	2	2	1
CO2	**3**	2	2	3	1
CO3	**3**	2	3	3	1
CO4	**2**	2	2	3	2
CO5	**3**	2	3	3	2

1 – Slightly; 2 – Moderately; 3 – Substantially

Transportation Engineering Lab II

Course Code:	**Credit: 4**
Teaching Scheme: Hrs/Week	**Examination Scheme:**
Practical: 2	ISE: 50
Tutorial:	
Self-Study:	ESE: 50

Course Outcomes: At the end of the course, the students demonstrate the ability to:

CO 1: Demonstrate the knowledge of various software related to Transportation Engineering

CO 2: Visit projects, prepare and present technical reports

CO 3: Analyze and apply solution for complex problems using advanced software

List of Laboratory Experiments

A. Students should carry out the following and prepare report for the same Mandatory

1. Use of statistical software for classification, dimension reduction, and forecasting.
2. Development of basic road network in microsimulation model
3. Characterization of Mixed Traffic in microsimulation model
4. Calibration of driving behaviour parameter for Indian traffic conditions
5. Demonstration of traffic calming measures in microsimulation model
6. Evaluation of results from microsimulation model
7. Design of Rigid Pavement using MS Excel as per IRC 58 (2015)

Any Three

1. Development of signal control system in microsimulation model
2. Design of Dowel Bar using MS Excel as per IRC 58 (2015)
3. Design of Tie Bar using MS Excel as per IRC 58 (2015)
4. Use advance highway design software: Developing sight distance profile for highway alignment, Evaluating existing horizontal and vertical curves, Super elevation development, Intersection design, Interchange design.
5. Solving case study problems in travel demand modelling with the help of transportation planning and econometric packages.

B. Field visits for studying Transportation Engineering

C. Students will carry out various assignments related to the courses taught in this semester given by the faculty teaching courses

References

1. Kadiyali, L.R., `Traffic Engineering and Transport Planning', Khanna Publications
2. Indian Highway Capacity Manual, 2017.
3. VISSIM Manual

Relevant IRC Codes

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

1 – Slightly; 2 – Moderately; 3 – Substantially

Technical Communication Skills

Course Code:		**Credit:**	2
Teaching Scheme		**Examination Scheme**	
Lectures:	1 Hrs	MSE: 50	Lab ISE: 100
Self-Study:	1 Hrs	TA: 50	
Lab:	2 Hrs		

Course Outcomes: Students will be able to:

1. Produce effective dialogue for business related situations
2. Use listening, speaking, reading and writing skills for communication purposes and attempt tasks by using functional grammar and vocabulary effectively
3. Analyze critically different concepts/principles of communication skill s
4. To appreciate, analyze, and evaluate business reports and research papers

Unit 1: Fundamentals of Communication **[4 Hrs]**

7 Cs of communication, common errors in English, enriching vocabulary, styles, and registers.

Unit 2: Aural-Oral Communication **[4 Hrs]**

The art of listening, stress and intonation, group discussion, oral presentation skills.

Unit 3: Reading and Writing **[8 Hrs]**

Types of reading, effective writing, business correspondence, interpretation of technical reports and research papers.

Textbooks:

[1] Raman Sharma, "Technical Communication", Oxford University Press.

[2] Raymond Murphy "Essential English Grammar" (Elementary & Intermediate) Cambridge University Press.

[3] Markel, M., & Rosson, P. (2024). Technical Communication (14th ed.). Bedford/St. Martin's.

[4] Shirley Taylor, "Model Business Letters, Emails and Other Business Documents" (seventh edition), Prentice Hall

[5] Thomas Huckin, Leslie Olsen "Technical writing and Professional Communications for Non-native speakers of English", McGraw Hill.

Reference Books:

[1] Thomas Huckin, Leslie Olsen "Technical writing and Professional Communications for Non-native speakers of English", McGraw Hill.

[2] Pfeiffer, W., & Goodall, H. L. (2024). Technical Communication: A Practical Approach. Pearson.

Web Resources:

[1] MIT OpenCourseWare – Technical Communication, https://ocw.mit.edu/courses/technical-communication

[2] Purdue OWL (Online Writing Lab) – Technical Writing, https://owl.purdue.edu/owl/subject_specific_writing/technical_writing/index.html

[3] IEEE Author Center – Resources for Writing Technical Papers, https://authorcenter.ieee.org

[4] Nature Masterclasses – Scientific Writing and Publishing, https://masterclasses.nature.com

[5] Toastmasters International – Public Speaking Resources, https://www.toastmasters.org/resources

[6] GitHub: Awesome Technical Writing, https://github.com/maestroj/awesome-technical-writing

[7] The Hemingway App: A tool for clear writing, http://www.hemingwayapp.com/

Liberal Learning

Teaching Scheme	Examination Scheme
Lectures:	**ISE: 100**
Lab : 2 hrs	
Self-study : 2 Hrs/week	**Credits : 1**

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

CO 1: Develop capacity to understand multidisciplinary sciences in a friendly manner.

CO 2: Create openness to diversity.

CO 3: Acquire ability to lead and examine life and value the need for life learning.

Student will be able to choose and enhance practical learning and application in the subject of his/her choice. One credit course spread over the semester to enhance practical learning and application.

- Dance
- Film Appreciation
- Music Vocal
- Painting
- Agriculture
- Business
- Clay Art & Pottery
- Corporate Culture
- Defense
- French
- Geography
- Holistic Health
- Modern Film Making
- Music (Instrumental)
- Photography
- Political Science
- Music (Vocal)
- Wood and Metal Art
- Japanese

SEMESTER III

Massive Open Online Course – I

Course Code: **Credit: 3**

Teaching Scheme	**Examination Scheme**
Lecture: 3 Hrs/week	CIE: 50
Self study : 1 Hrs/week	ESE: 50

Course Outcomes: Students will be able to:

1. Acquire new skills or knowledge to enhance their personal and professional development.
2. Receive a flexible learning environment, allowing one to study at own pace and convenience.
3. Opportunity for lifelong learning.
4. Foster collaboration and networking among participants.

The students in consultation with the faculty advisor, opt for a single course of 12 weeks offered by the NPTEL in the current semester. The students need to register for the examination conducted by the NPTEL.

Massive Open Online Course – II

Course Code:	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Lecture: 3 Hrs/week	CIE: 50
Self study : 1 Hrs/week	ESE: 50

Course Outcomes: Students will be able to:

1. Acquire new skills or knowledge to enhance their personal and professional development.
2. Receive a flexible learning environment, allowing one to study at own pace and convenience.
3. Opportunity for lifelong learning.
4. Foster collaboration and networking among participants.

The students in consultation with the faculty advisor, opt for a single course of 12 weeks offered by the NPTEL in the current semester. The students need to register for the examination conducted by the NPTEL.

Dissertation Phase – I

Course Code:		**Credit: 11**	
Teaching Scheme		**Examination Scheme**	
Lab:	22 Hrs	CIE:	70
Self-Study:	12 Hrs	ESE:	30

Course Outcomes: Students will be able to:

1. Demonstrate how to search the existing literature to gather information about a specific problem or domain.
2. Identify the state-of-the-art technologies and research in the chosen domain and highlight open problems that are relevant to societal or industrial needs.
3. Evaluate various solution techniques to determine the most feasible solution within the given constraints for the chosen dissertation problem.
4. Apply software engineering principles related to requirements gathering and design to produce relevant documentation.
5. Write a dissertation report that details the research problem, objectives, literature review, and solution architecture.
6. Deliver effective oral presentations to communicate the findings and outcomes of the research work.

Guidelines:

The dissertation is a year-long project, conducted and evaluated in two phases. It can be carried out either in-house or within an industry as assigned by the department. The project topic and internal advisor (a faculty member from the department) are determined at the beginning of Phase I.

Students are expected to complete the following activities in Phase-I:

1. Literature survey
2. Problem Definition
3. Motivation for study and Objectives
4. Preliminary design /feasibility / modular approaches

Deliverables:

1. A report having the following details: Abstract, Problem statement, Requirements specification, Literature survey, Proposed solution, High-level design description, Plan for implementation and testing in Phase-II
2. A presentation that covers the major points covered in the report.

Evaluation:

Two independent assessments (Mid-Semester and End-Semester evaluations) will be made. In both the Examinations, the internal guide, along with a Senior Faculty member of the department, will evaluate the work. The marks obtained in these two assessments will be combined to get the final evaluation out of 100 marks. The course grading, like other courses, will be relative in nature.

The evaluation will take place based on criteria such as literature survey and well-defined project problem statement, proposed high level system design, concrete plan for implementation and result generation, presentation etc.

The panel (external examiner(s) and senior faculty) will provide a report about suggestions/changes to be incorporated during phase-II.

SEMESTER IV

Dissertation Phase – II

Course Code: **Credit: 11**

Teaching Scheme		**Examination Scheme**	
Lab:	22 Hrs	CIE:	70
Self-Study:	12 Hrs	ESE:	30

Course Outcomes: Students will be able to:

1. Achieve proficiency in the languages, tools, libraries, and technologies used in the dissertation work.
2. Apply project planning principles and techniques to ensure effective and efficient project execution.
3. Demonstrate an understanding of the entire lifecycle of a software product or solution.
4. Produce artifacts such as source code, test plans, and test results based on the dissertation work.
5. Write research paper(s) and a thesis in accordance with publication ethics.
6. Exhibit the presentation skills needed to effectively present the work at various platforms.

Guidelines:

Students are expected to complete the following activities in Phase-II:

1. Implementation of the proposed approach in the first stage
2. Testing and verification of the implemented solution
3. Writing of a report and presentation
4. Publish the work done at a suitable Scopus indexed conference/in a journal

Deliverables:

1. Source code (if the project is in-house)
2. Dissertation report that gives overview of the problem statement, literature survey, design, implementation details, testing strategy and results of testing
3. All the artifacts created throughout the duration of dissertation such as requirements specification, design, project plan, test cases etc
4. Presentation based on the dissertation report
5. Research Paper(s) based on the dissertation work

Evaluation:

Mid-Semester evaluation: In the MSE, the internal guide, along with a Senior Faculty of the department, will evaluate the work. In the End Semester Examination evaluation, the internal guide, along with an external expert (usually from an Industry) will evaluate the work. The marks obtained in these two assessments will be combined to get the final evaluation out of 100 marks. The course grading, like other courses, will be relative in nature. The assessment is done on the criteria such as concrete system design, implementation status and concrete plan for completion of remaining tasks, presentation etc. The purpose of Mid-Semester evaluation is also to check preparedness of students for the End-Semester evaluation. Examiners may give suggestions for changes/corrections to be incorporated before the final evaluation. If the work done till then may not lead to successful completion of the dissertation in the remaining time, the student may be asked to take an extension in time to complete the course.

End-Semester evaluation: The assessment of End-Semester evaluation will be done based on the criteria such as quality of implementation, result analysis, project outcomes (publications, patent, copyright, contribution to opensource community, participation in project competition etc.), quality of report, presentation etc. The total assessment of phase-II work is for 100 marks and the grading, like other courses, will be relative.