16MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

(AUTONOMOUS)

DEPARTMENT OF CIVIL ENGINEERING

M.Tech
in
TRANSPORTATION ENGINEERING

M. TECH DEGREE PROGRAMME in TRANSPORTATION ENGINEERING

CURRICULUM & SYLLABI

Items	Board of Studies (BoS)	Academic Council (AC)
Date of Approval	16/02/2026	12/03/2026

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

(Approved by AICTE, Autonomous Institution Affiliated to APJ Abdul Kalam Technological University)
MAR IVANIOS VIDYANAGAR, NALANCHIRA, THIRUVANANTHAPURAM – 695015, KERALA.
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CURRICULUM & SYLLABI

for

M. TECH DEGREE PROGRAMME

in

TRANSPORTATION ENGINEERING

2026 SCHEME (AUTONOMOUS)

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MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY
(Autonomous)

Vision and Mission of the Institution

Vision

To be an Institution moulding globally competent professionals as epitomes of Noble Values.

Mission

To transform the Youth as technically competent, ethically sound and socially committed professionals, by providing a vibrant learning ambience for the welfare of humanity.

DEPARTMENT OF CIVIL ENGINEERING

Vision and Mission of the Department

Vision

To be a Centre of Excellence in Civil Engineering education with a global perspective, creating ethically strong engineers for the service of society.

Mission

To provide Engineering Education which can create exemplary professional Civil Engineersof high ethics with strong conceptual foundation coupled with practical insight, to serve the industry and community.

M.TECH IN TRANSPORTATION ENGINEERING

PROGRAMME OUTCOMES (POs)

Program outcomes are the attributes that are expected to be demonstrated by a graduate after completing the course.

PO1: An ability to independently carry out research/ investigation and development work in engineering and allied streams

PO2: An ability to communicate effectively, write and present technical reports on complex engineering activities by interacting with the engineering fraternity and with society at large.

PO3: An ability to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PO4: An ability to apply stream knowledge to design or develop solutions for real world problems by following the standards

PO5: An ability to identify, select and apply appropriate techniques, resources and state-of-the-art tool to model, analyze and solve practical engineering problems.

PO6: An ability to engage in life-long learning for the design and development related to the stream related problems taking into consideration sustainability, societal, ethical and environmental aspects

PO7: An ability to develop cognitive load management skills related to project management and finance which focus on Entrepreneurship and Industry relevance.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO 1: An ability to analyze, design and evaluate transportation systems including traffic operations, highway geometrics and pavement performance to ensure safe, efficient and sustainable mobility.

PSO 2: An ability to utilize modern engineering tools and emerging technologies to model, analyze and optimize transportation infrastructure and services, and to develop innovative solutions for complex transportation engineering problems.

CONTENTS

1. Semester-wise Distribution of the Courses

a) Semester I (M1)

Slot	Course Type	Course Code	Course	Marks		Hours L – T – P	Credits
				CIA	ESE		
A	PCC	26CE261A	Analysis and Design of Pavement Systems	50	50	4 – 0 – 0	4
B	PCC	26CE261B	Traffic Engineering	50	50	4 – 0 – 0	4
C	PCC	26CE261C	Urban Transportation Planning	50	50	4 – 0 – 0	4
D	PEC/ PECP	26CE262X	Program Elective Course1/ Program Elective Course with practical component 1	50	50	3 – 0 – 0/ 2 – 0 – 2	3
E	PEC/ PECP	26CE262X	Program Elective Course2/ Program Elective Course with practical component 2	50	50	3 – 0 – 0/ 2 – 0 – 2	3
S	AC	26AC061A	Research Methodology and IPR	50	50	2 – 0 – 0	0
T	LBC	26CE269A	Pavement Materials and Evaluation Lab	100	–	0 – 0 – 3	2
			Total	**400**	**300**	**23 – 28**	**20**

Teaching Assistance: upto 6 hours

Program Elective Courses and Program Elective Course with practical component in M1 and M2 must be chosen from a single basket of all PECs and PECPs.

b) Semester II (M2)

Slot	Course Type	Course Code	Course	Marks		Hours L - T - P	Credits
				CIA	ESE		
A	PCC	26MA061D	Probability, Statistics and Mathematical Techniques	50	50	4 – 0 – 0	4
B	PEC/ PECP	26CE262X	Program Elective Course 3/ Program Elective Course with practical component 3	50	50	3 – 0 – 0/ 2 – 0 – 2	3
C	PEC/ PECP	26CE262X	Program Elective Course 4/ Program Elective Course with practical component 4	50	50	3 – 0 – 0/ 2 – 0 – 2	3
D	IEC/ SAEC*	26CE266X/ 26CE064X	Industry Elective / (Skill/Ability Enhancement Course)	50	50	3 – 0 – 0/ 2 – 0 – 2	3
S	PR	26CE267A	Mini project	100	–	0 – 0 – 6	3
T	LBC	26CE269B	Transportation Planning and Traffic Lab	100	–	0 – 0 – 3	2
			Total	**400**	**200**	**22 – 26**	**18**

Teaching Assistance: Upto 6 hours

***Marks / GPA earned in this SAEC will be used for awarding GPA for this course.

c) Semester III (M3)

Slot	Course Type	Course Code	Course	Marks		Hours L - T - P	Credits
				CIA	ESE		
A	SAEC**	26CE074X	Skill/ Ability Enhancement Course	To be successfully completed		–	3
D	PR	26CE278A	Project (Phase I)/ Internship	100 100 100	– 100 –	0 – 0 – 24 0 – 0 – 24 Industry norms	16
			Total	**100**	**–/100/–**	**24**	**19**

Teaching Assistance for students doing Project (Phase I)/ Project in the college: 5 hours

** This SAEC can be carried out at any time from M1 to M3, and credited in M3.

d) Semester IV (M4)

Slot	Course Type	Course Code	Course	Marks		Hours L - T - P	Credits
				CIA	ESE		
D	PR	26CE278B	Project (Phase II) / Internship	100 100 100	100 – 100	0 – 0 – 24 Industry norms 0 – 0 – 24	16
Total				**100**	**100/– /100**	**24/ Industry norms**	**16**

Teaching Assistance for students doing Project (Phase II)/ Project in the college: 5 hours

a) LIST OF PROGRAMME ELECTIVE COURSES

Category Code	Course Number	Course Name	L	T	P	Credit
PEC	26CE262A	Geometric Design of Highways	3	0	0	3
	26CE262B	Advanced Pavement Materials	3	0	0	3
	26CE262C	Pavement Construction and Maintenance	3	0	0	3
	26CE262D	Pavement Asset Management	3	0	0	3
	26CE262E	Traffic Flow Theory	3	0	0	3
	26CE262F	Traffic Simulation Modelling and Applications	3	0	0	3
	26CE262G	Transportation Network Analysis	3	0	0	3
	26CE262H	Road Safety Management	3	0	0	3
	26CE262I	Multimodal Transit Systems	3	0	0	3
	26CE262J	Geoinformatics in Transportation Engineering	2	0	2	3
	26CE262K	Analytical Techniques in Transportation Planning	3	0	0	3
	26CE262L	Green Transportation Systems	3	0	0	3
	26CE262M	Advanced Optimization Techniques for Transportation Engineering	3	0	0	3
	26CE262N	Economic Appraisal of Projects	3	0	0	3
	26CE062A	Data Science and ML in Civil Engineering	3	0	0	3

b) LIST OF INDUSTRY ELECTIVE COURSES

Category Code	Course Number	Course Name	L	T	P	Credit
IEC	26CE266A	Highway Asset Management	3	0	0	3

2. SYLLABI FOR VARIOUS COURSES

(a) PROGRAMME CORE COURSES

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26CE261A	Analysis and Design of Pavement Systems	PCC	4	0	0	4	2026

i) COURSE OBJECTIVES

The objective of this course is to provide a strong foundation in the analysis and design of pavements. It covers axle load analysis, material characterization, and stress–strain analysis for pavement design. The syllabus includes the design of flexible and rigid pavements using internationally adopted approaches. Students will be introduced to software tools used for pavement analysis and design. In addition, the course addresses overlay design for pavement rehabilitation.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Apply the fundamental concepts of stress distribution in a pavement system to evaluate the critical stresses and strains.	Apply
CO2	Apply appropriate techniques for axle load data analysis and material characterization for the design of pavements.	Apply
CO3	Design flexible pavements and overlays as per different codes of practice.	Apply
CO4	Apply standard provisions to design rigid pavements.	Apply
CO5	Analyze various design options using relevant software for the analysis and design of pavements.	Analyze

iii) SYLLABUS

Introduction to pavements: components, subsystems, and factors affecting pavement design.

Material characterization and failure criteria for pavement design.

Analysis of axle loads for pavement design.

Stresses and strains in flexible pavements, Design of flexible pavements using the AASHTO Method, Asphalt Institute Method, and IRC Method.

Stresses in rigid pavements, Design of rigid pavements using the PCA Method, AASHTO (1993) Method, and IRC Method.

Introduction to Mechanistic–Empirical Pavement Design (MEPDG 2004).

Evaluation and rehabilitation design of pavement systems for structural adequacy and functional performance.

Use of software tools for pavement analysis and design.

iv) REFERENCES

1) Yang H. Huang, *Pavement Analysis and Design*, Prentice Hall, 2nd edition, 2008.

2) Papagiannakis, A. T. and Masad, E. A., Pavement Design and Materials, Wiley, 2nd edition, 2024.

3) IRC: 37-2018, *Guidelines for the Design of Flexible Pavements*, Fourth revision, Indian Roads Congress, New Delhi, 2018.

4) IRC: 58-2015, *Guidelines for the Design of Plain Jointed Rigid Pavements for Highways*, Fourth revision, Indian Roads Congress, New Delhi, 2015.

5) AASHTO 1993 - *Guide for Design of Pavement Structures*, American Association of State Highway and Transportation Officials, Washington, D.C., 1993.

6) National Cooperative Highway Research Program, *Guide for Mechanistic-Empirical Design of New and Rehabilitated Pavement Structures,* Transportation Research Board, National Research Council, Illinois, 2004.

7) MS-01-2001, *Thickness Design: Asphalt Pavements for Highways & Streets (Manual Series 1)*, The Asphalt Institute, 2001.

8) EB109.01P - *Thickness Design for Concrete Highway and Street Pavements (1984)*, Portland Cement Association, Skokie, Ill.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Fundamentals and Structural Analysis of Pavements** Types of pavements: flexible, rigid, and composite pavements, Pavement cross-section and functions of individual layers. Pavement distresses: rutting, fatigue cracking, temperature cracking, moisture damage, and roughness (IRI). Failure criteria for the design of flexible pavements. Boussinesq's theory for a homogeneous elastic half-space, Burmister's layered theory, Analytical solutions for one-, two-, and three-layer pavement systems. Identification of critical stresses and strains in flexible pavements.	**12**
II	**Traffic Loading** Traffic characteristics: traffic volume, growth rate, lane distribution factor, and directional distribution. Axle configurations and axle load spectra. Equivalent Single Wheel Load (ESWL) for different design criteria, Axle load surveys and load distribution, Truck factor and Equivalent Single Axle Load (ESAL) computation, Design traffic estimation. **Material Characterization** Characterization of soils, granular materials, and bituminous materials - Resilient modulus of subgrade and granular layers, Dynamic modulus of bituminous mixtures, Fatigue and rutting characteristics of bituminous materials, Modulus of subgrade reaction (k-value) for rigid pavements. Influence of climate on material properties.	**12**

III	**Flexible Pavement Analysis and Design** Methods of flexible pavement design: AASHTO (1993) Method, Asphalt Institute Method, and IRC:37 Method. Reliability concepts in flexible pavement design. Mechanistic–Empirical Pavement Design (MEPD): concept and framework. Mechanistic response parameters (critical stresses and strains). Transfer functions for fatigue and rutting, Basic fatigue and rutting prediction models Introduction to IRI and performance progression concepts, Damage accumulation principles. Use of current software tools for the analysis and design of flexible pavements.	**12**
IV	**Rigid Pavement Analysis and Design** Stress analysis: Westergaard's theory and underlying assumptions, Types of stresses—wheel load stresses (interior, edge, and corner), temperature stresses, and frictional stresses, Critical combinations of stresses. Rigid pavement design using the PCA method, AASHTO (1993) method, and IRC:58 method, Design inputs and reliability considerations. Use of current software tools for the analysis and design of rigid pavements.	**12**
V	**Evaluation and Overlay Design** Evaluation of In-Service Pavements - Structural and functional evaluation of pavements, Deflection-based evaluation concepts. Principles of overlay design. Overlay Design - Bituminous overlays over bituminous pavements, Concrete overlays over concrete pavements, Bonded, unbonded, and partially bonded overlay systems, Thickness design approaches and performance considerations.	**12**
	Total hours	**60**

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26CE261B	Traffic Engineering	PCC	4	0	0	4	2026

i) COURSE OBJECTIVES

This course gives an introduction to the concepts of traffic engineering, fundamental flow relationships, traffic surveys, traffic engineering control systems, traffic management measures and the rules and regulations pertaining to traffic engineering.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Identify the microscopic and macroscopic characteristics of a traffic stream.	Apply
CO2	Experiment with the relationship between fundamental parameters of a traffic stream.	Apply
CO3	Apply different statistical techniques to interpret the data collected through various traffic surveys.	Apply
CO4	Apply standard procedures to design appropriate traffic control measures at a road intersection.	Apply
CO5	Identify appropriate safety measures, regulations and management measures for a given traffic scenario.	Apply

iii) SYLLABUS

Components and characteristics of traffic stream, Traffic stream parameters – Fundamental diagrams of traffic flow.

Shock wave, PCU concepts, Traffic surveys – Data collection and analysis, Measurement of traffic parameters.

Studies on parking, headway, pedestrian, accident, intersection and congestion, Sampling and statistical analysis.

Design of at intersections – signals, roundabouts, channelization, Capacity and Level of Service (LOS), Introduction to traffic simulation.

Traffic controls and regulations, Traffic laws and ordinances, traffic management techniques, Transit service improvement measures.

iv) REFERENCES

1) Roess R. P., McShane W. R. and Prassas E.S., Traffic Engineering, Pearson, 5 th edition, 2019.
2) Pignataro L. J., Traffic Engineering -Theory and Practice, Prentice Hall, 1973 (Digitized in 2011).
3) Dr. L. R. Kadiyali, Traffic Engineering and Transport Planning, Khanna Publishers, 9th edition, 2017 (Second Reprint 2025).
4) C. Jotin Khisty and B. Kent Lall, Transportation Engineering, Pearson Education, 3rd

edition, 2017.

5) C. S. Papacostas and P.D. Prevedouros, Transportation Engineering and Planning, Pearson Education, 3rd edition, 2015.
6) Fred L. Mannering and Scott S. Washburn, Principles of Highway Engineering and Traffic Analysis, John Wiley and Sons, 5th edition, 2012.
7) Nicholas J. Garber and Lester A. Hoel, Traffic and Highway Engineering, Cengage India Pvt. Ltd., 5th edition, 2015.
8) Averill M. Law, Simulation Modeling and Analysis, McGraw Hill Education, 5th edition, 2014.
9) IRC:93-1985, Guidelines on Design and Installation of Road Traffic Signals, Indian Roads Congress, New Delhi, 1985.
10) IRC: 86-2018, Geometric Design Standards for Urban Roads and Streets, Indian Roads Congress, New Delhi, 2018.
11) IRC: 64-1990, Guidelines for Capacity of Roads in Rural Areas, Indian Roads Congress, New Delhi, 1990.
12) IRC: 93-1985, Guidelines on Design and Installation of Road Traffic Signals, Indian Roads Congress, New Delhi, 1985.
13) IRC: 106-1990, Guidelines for Capacity of Urban Roads in Plain Areas, Indian Roads Congress, New Delhi.
14) IRC SP: 41-1994, Guidelines for the Design of At-Grade Intersections in Rural and Urban Areas, Indian Roads Congress, New Delhi, 1994.
15) IRC: 67-2012, Code of Practice for Road Signs, Indian Roads Congress, New Delhi, 2012.
16) Indian Highway Capacity Manual (INDO-HCM), Chandra, S., Gangopadhyay S., Velmurugan S. and Ravinder K., CSIR-CRRI, 2017.
17) IRC: SP:88-2019, Manual on Road Safety Audit, 1st revision, Indian Roads Congress, New Delhi, 2019.

v) COURSE PLAN

Module	Contents	No. of hours
I	Objectives and scope of traffic engineering, Components and characteristics of traffic stream - Microscopic and macroscopic characteristics. Components of road traffic: Static and dynamic characteristics of vehicles, driver and road user, road characteristics. **Traffic stream parameters**: Fundamental diagrams of traffic flow, Time-space diagram.	**12**
II	**Flow at different densities:** Shock wave phenomenon. Car-following theory, Concept of PCU and methods of determination of PCU values, Studies on PCU determination under heterogeneous traffic. **Traffic Surveys:** Data collection and analysis, Measurement of traffic parameters - speed, volume, density.	**12**

III	Travel time and delay, headways and gaps, Critical Gap – Gap acceptance studies, Intersection studies, Origin and destination studies. Parking studies, Pedestrian studies, Accident studies. Congestion studies – performance measures, intensity, traveler perception, remedial measures. Analysis of traffic data – fitting of distributions, sampling in traffic studies, statistical analysis of traffic stream parameters.	**12**
IV	Design of at-grade intersections, Channelization, Design of rotaries. Design of traffic signals- pre timed and actuated, phase diagrams, timing diagram, Signal coordination. Capacity and Level of service (LOS) - definitions, factors affecting LOS, capacity and performance evaluation. Introduction to traffic simulation - different types, application of traffic simulation models for analysis of dynamic traffic systems.	**13**
V	**Traffic Controls and Regulation**: Traffic signs and road markings, Other traffic control aids, Advanced technologies of traffic control. **Traffic laws and ordinances**: General regulations, Regulations on vehicles, drivers, pedestrians and traffic, Parking regulations. Regulations on speed- speed zoning, Enforcement of regulations. **Traffic Management techniques**: One-way, Tidal flow, Traffic diversion, Turning restrictions, Congestion pricing, High peak period tolls, Traffic calming measures. Transit service improvement measures, Road safety audit and safety measures (concept only).	**11**
	Total hours	**60**

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26CE261C	Urban Transportation Planning	PCC	4	0	0	4	2026

i) COURSE OBJECTIVES

This course gives an introduction to the concepts of the transportation planning process, such as trip generation, trip distribution, modal split and trip assignment.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Apply the concepts and principles of urban transportation planning for travel demand estimation and forecasting.	Apply
CO2	Analyze trip generation and trip distribution models for urban areas.	Analyze
CO3	Evaluate mode choice behaviour using appropriate aggregate and disaggregate models.	Apply
CO4	Develop transportation networks and perform traffic assignment based on optimal travel cost and time.	Analyze
CO5	Apply land use–transport interaction models and planning concepts to solve urban transportation problems.	Apply

iii) SYLLABUS

Urban transportation planning concepts, objectives, planning methodologies and conventional planning process.

Travel demand estimation and trip generation models including trip rate, category and regression approaches.

Trip distribution models including growth factor, gravity, opportunity and linear programming approaches.

Mode split analysis and mode choice behaviour using aggregate, disaggregate and probabilistic models.

Traffic assignment methods and route choice behaviour. Introduction to land use–transport interaction models and planning applications.

iv) REFERENCES

1) Dr. L. R. Kadiyali, Traffic Engineering and Transport Planning, Khanna Publishers, 9th edition, 2017 (Second Reprint 2025).
2) C. Jotin Khisty and B. Kent Lall, Transportation Engineering, Pearson Education, 3rd edition, 2017.
3) Hutchinson, B.G., Principles of Urban Transportation System Planning, Mc-Graw Hill 1990.
4) Bruton M.J., Introduction to Transportation Planning, Hutchinson of London, 2000.
5) Venkatramaiah, Transportation Engineering, Vol: 1, Universities Press (India), Pvt.Ltd.,

2016.

6) John W. Dickey, Walter J. Diewald, Antoine G. Hobeika, Charles J. Hurst, N. Thomas Stephens, Robert C. Stuart and Richard D. Walker, Metropolitan Transportation Planning, 2nd edition, Routledge (imprint of Taylor and Francis), 2017 (e-book).

7) NPTEL lectures on Transportation Planning, Dr. V. Tamil Arasan, Former Professor of IITM, 2012.

8) C. S. Papacostas and P.D. Prevedouros, Transportation Engineering and Planning, 2nd edition, Prentice Hall, 1992.

9) Michael D Meyer and Eric J Miller, Urban Transportation Planning: A Decision Oriented Approach, McGraw Hill, 1984.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction and scope of urban transportation planning – Definition and basic principles, Role of transportation in urban development, Changing concerns of society, Goals and objectives, Hierarchical levels of transportation planning, Transportation problems and problem domain, Planning constraints, Types of transportation planning models. Conventional transportation planning process – Inventory, Model building, Forecasting and evaluation, Planning in systems engineering framework. Concept of travel demand – Travel behaviour, Travel attributes and independent variables, Definition of study area and zoning.	**12**
II	**Methods of travel demand estimation:** Assumptions in demand estimation, Sequential, recursive and simultaneous planning processes. Introduction to transportation planning surveys and practices. **Trip classification:** Trip productions and attractions. **Trip generation analysis:** Trip generation models: trip rate analysis, category analysis, multiple regression models, Household models – Trip attraction characteristics of work centres and commercial areas.	**12**
III	**Trip distribution analysis:** Trip-end and trip-interchange concepts, Growth factor models, Fratar and Furness methods, Gravity model – formulation and calibration, Opportunity models – intervening opportunity and competing opportunity models , Entropy-based trip distribution models, Linear programming approach to trip distribution, Estimation of travel demand based on link volume philosophy.	**12**
IV	**Mode split analysis**: Mode choice behaviour, Competing modes, Mode split curves, Behavioural models in transportation planning, Utility theory and utility functions, Probabilistic models – Aggregate and disaggregate mode split models, Logit and probit models, Discriminant analysis, Two-stage mode split models, Factors influencing mode choice decisions.	**12**

V	**Traffic assignment concepts**: Transportation networks – Links, nodes and coding, Route building and route choice behaviour, Minimum path algorithms. **Traffic assignment methods**: all-or-nothing assignment, capacity restrained assignment, multipath assignment, incremental and equilibrium assignment. Graph theory applications in transportation network analysis, Introduction to transport planning software. **Land use–transport interaction**: Historical development, Lowry derivative models, ISGLUTI study, Recent developments in land use, Transport modelling, Preparation of alternative transportation plans, Evaluation techniques and plan implementation, Case studies on transportation planning and econometric packages. Introduction to computer-based calibration of travel demand, land use and land use–transport models.	**12**
	Total hours	**60**

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26MA061D	Probability, Statistics and Mathematical Techniques	PCC	4	0	0	4	2026

i) COURSE OBJECTIVES

The objective of the course is to equip students with concepts of probability distributions, statistical inference, regression and multivariate analysis, experimental design, transportation optimization problems, and time series techniques, with emphasis on applications in transportation data analysis and modelling.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Apply probability distributions to fit appropriate models for transportation engineering data.	Apply
CO2	Apply statistical inference techniques to assess population characteristics and test hypotheses using sample data.	Apply
CO3	Apply optimization techniques to obtain optimal solutions for transportation-related problems.	Apply
CO4	Apply time series models to analyze trends and patterns in transportation system data.	Apply
CO5	Apply principal component analysis and related multivariate techniques for dimensionality reduction of transportation datasets.	Apply

iii) SYLLABUS

Probability mass functions and probability density functions – distribution functions, mean and variance, fitting of distributions, applications.

Statistical inference – sampling distributions, testing of hypotheses, Regression analysis, curve fitting.

Analysis of variance – Randomized block designs, latin square designs, applications, Transportation problem.

Time series models – testing of ARIMA models.

Multivariate Analysis – covariance matrix and principal components.

iv) REFERENCES

1) S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand and Sons, 12th edition, 2020.
2) Richard A. Johnson, Irwin Miller and John Freund, Miller and Freund's Probability and Statistics for Engineers, Pearson Education India, 8th edition, 2015.
3) Jack R. Benjamin and C. Allin Cornell, Probability Statistics and Decision for Civil Engineers: Volume 38, Dover Publications, 1st edition, 2014.
4) Dallas E. Johnson, Applied Multivariate Methods for Data Analysis, Duxbury Press, 1st

edition, 1998.

5) Jay L DeVore, Probability and Statistics for Engineering and the Sciences, Cengage Learning, Inc, 8th edition, 2011.
6) Richard A. Johnson and Dean W. Wichern, Applied Multivariate Statistical Analysis, Prentice Hall India Learning Pvt. Ltd., 2012.
7) Irwin Miller and Marylees Miller, John E. Freund's Mathematical Statistics with Applications, Pearson Education Ltd., 2013.
8) S. D. Sharma, Operations Research, Kedar Nath and Ram Nath, 1st edition, 2008.
9) David C Lay, Steven R. Lay and Judi J. McDonald, Linear Algebra and its Applications, Pearson Education, 5th edition, 2023.
10) Simon Washington, Matthew G. Karlaftis and Fred Mannering, Statistical and Econometric Methods for Transportation Data Analysis, Chapman and Hall/CRC Interdisciplinary Statistics, 3rd edition, 2020.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Probability Distributions:** Probability mass functions and probability density functions, Distribution functions, Mean, variance, moments. Standard distributions: Binomial, Poisson, Exponential, Gamma and Normal, Fitting of distributions, Applications using transportation related datasets (traffic volume, travel time).	12
II	**Statistical Inference and Regression**: Statistical inference and sampling distributions, Interval estimation of population parameters, Testing of hypotheses, Large sample tests for mean and proportion. **Parametric tests**: t-test, F-test, Chi-square test, Linear regression and correlation, Curve fitting using method of least squares, Simple and multiple linear regression, Introduction to diagnostic checking of regression models (conceptual).	14
III	**Experimental Design & Transportation Optimization**: Analysis of variance (ANOVA) - one-way designs, Randomized Block Designs (RBD), Factorial experiments (introductory concepts), Latin Square Designs, Applications in engineering studies, Transportation problem, Balanced and unbalanced transportation problems, Initial basic feasible solution using Vogel's Approximation Method (VAM), Optimal solution using MODI method, Interpretation of solutions in transportation planning context.	13
IV	**Time Series Analysis**: Components of time series, Smoothing techniques, Measuring forecasting accuracy, Trend and seasonality interpretation for traffic and demand data, Time series models, Testing and basic interpretation of ARIMA models.	9
V	**Multivariate Analysis**: Covariance matrix and correlation matrix, Multivariate normal distribution (conceptual), Principal Component	12

	Analysis (PCA), Sample variation explained by principal components, Graphical interpretation of principal components, Application of PCA to transportation data (overview).	
	Total hours	**60**

2. SYLLABI FOR VARIOUS COURSES

(b) PROGRAMME ELECTIVE COURSES/ PROGRAMME ELECTIVE COURSE WITH PRACTICAL COMPONENT

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26CE262A	Geometric Design of Highways	PEC	3		0	3	2026

i) COURSE OBJECTIVES

Goal of this course is to expose the students to the concepts of geometric design elements and the cross-sectional elements. It enables the students to determine the sight distances and the components of horizontal and vertical alignment. It also enables the students to design the various types of intersections, their suitability and various types of facilities for pedestrians, cycles, buses and parking.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Identify the most suitable cross section while designing a roadway.	Apply
CO2	Apply standard guidelines for the geometric design of horizontal and vertical alignment of different classes of highways.	Apply
CO3	Identify appropriate geometric design for a given intersection.	Apply
CO4	Apply relevant guidelines and standards for the design of pedestrian facilities, bus bays, parking facilities, cycle tracks, street lighting and drainage systems.	Apply

iii) SYLLABUS

Geometric design controls, cross-section elements for rural/urban roads, road furniture, and roadside safety; sight distances, horizontal/vertical alignments, lane determination, trial alignment techniques, and highway capacity per IRC/Indo HCM

Cross section elements, design specifications, pavement surface characteristics, horizontal alignment of roads, vertical alignment of roads.

At-grade and grade-separated intersections, channelisation, traffic islands, roundabouts, and interchange street lighting design principles and road safety measures including accident analysis and counter measures;

Ancillary facilities like pedestrian/cycle tracks, bus/truck terminals, parking, toll plazas, and surface/sub-surface drainage.

iv) REFERENCES

1) AASHTO-2011, A Policy on Geometric Design of Highways and Streets, 6th edition, American Association of State Highway and Transportation Officials, Washington D.C., 2011.
2) L.R. Kadiyali and N.B. Lal, Principles and Practice of Highway Engineering, 7th edition, Khanna Publishers, 2019.
3) Khanna S.K., Justo C. E. G. and Veeraragavan A., Highway Engineering, 10th edition, Nem Chand and Bros., 2019.
4) Great Britain Ministry of Transport, Roads in Urban Areas, HMSO, London, 1974.

5) Jack E Leish and Associates, Planning and Design Guide: At-Grade Intersections, A Design Reference Book and Text, Undated.
6) IRC: 86-2018, Geometric Design Standards for Urban Roads and Streets, Indian Roads Congress, New Delhi, 2018.
7) IRC: 52- 2001, Recommendations about Alignment Survey and Geometric Design of Hill Roads, Indian Roads Congress, New Delhi, 2001.
8) IRC: 64-1990, Guidelines for Capacity of Roads in Rural Areas, Indian Roads Congress, New Delhi, 1990.
9) IRC: 3-1983, Dimensions and Weights of Road Design Vehicles, Indian Roads Congress, New Delhi, 1983.
10) IRC: 38-1988, Guidelines for Design of Horizontal Curves for Highways and Design Tables (First Revision), Indian Roads Congress, New Delhi,1988.
11) IRC: 66-1976, Recommended Practice for Sight Distance on Rural Highways, Indian Roads Congress, New Delhi,1976.
12) IRC: 65-2017, Guidelines for Planning and Design of Roundabouts (First Revision, Indian Roads Congress, New Delhi, 2017.
13) IRC: 92-2017, Guidelines for the Design of Interchanges in Urban Areas (First Revision), Indian Roads Congress, New Delhi, 2017.
14) IRC: 103-2012, Guidelines for Pedestrian Facilities, 1st Revision, Indian Roads Congress, New Delhi, 2012.
15) IRC SP: 41-1994, Guidelines for the Design of At-Grade Intersections in Rural and Urban Areas, Indian Roads Congress, New Delhi, 1994.

v) COURSE PLAN

Module	Contents	No. of hours
I	Functional Classification of Highway System, Design Controls – Topography, Driver characteristics, Vehicle Characteristics, Traffic, Capacity and Level of Service, Design Speed. Objectives of Geometric Design, Cross Section Elements: Typical cross-sections for rural highways, urban streets, divided and undivided roads, specific elements – bicycle and pedestrian facility, service road. Design specifications; Pavement Surface characteristics – Skid Resistance, Road Roughness; Camber, Objectives, design standards. Specifications for hill roads. Road furniture - longitudinal markings, junction markings, object markings, messages, road traffic signs, delineators, speed breakers. Roadside design and clear zones, traffic barriers, safety components.	**9**
II	Geometric elements: sight distance, horizontal alignment, vertical alignment Determination of required number of lanes, design of turning path. Highway location and alignment design: location study, developing trial alignment, evaluating impacts, single line sketching technique.	**10**

	Highway capacity: two lane, four lane, six lane, non-urban highways, urban roads, expressways, Indo HCM and IRC specifications.	
III	Intersections: Classification of intersections, at-grade and grade-separated; principles of intersection design – conflict points, speed change, visibility, channelisation and safety. Design of at-grade intersections: simple, staggered and skew intersections; traffic islands and channelisation principles; design of roundabouts – basic geometry and capacity concepts. Grade-separated intersections (interchanges): types (diamond, cloverleaf, trumpet, directional), warrants and basic layout considerations; acceleration and deceleration lanes, weaving sections.	**9**
IV	Ancillary Facilities: Design of pedestrian and bicycle facilities, sidewalks, crosswalks, refuges, cycle tracks; design of bus shelters and bus bays, bus terminal, truck terminal and truck lay-by, container terminal, toll plaza, foot over bridge and sky walk, on-street and off-street parking layouts, multi storied parking. Drainage facilities: importance, principles, drainage of various geometric elements, surface and sub surface drainage.	**10**
V	Design of Street Lighting: Definitions and background, pavement luminance and measurement, illumination level, Veiling Luminance, longitudinal uniformity, utilisation factor, depreciation factor, maintenance factor, traffic criteria, warranting conditions, and design practices. Introduction to civil 3D software for geometric design of highways.	**8**
	Total hours	**45**

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26CE262B	Advanced Pavement Materials	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

The main objective of this course is to provide a thorough understanding of material characterization for bituminous and concrete pavements. The course includes topics on the stabilization of weak subgrade soils. It also deals with various sustainable materials used in pavement construction.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Identify the suitability of soil for highway construction and its use in pavement layers through in-situ and laboratory investigations.	Apply
CO2	Apply various techniques for soil stabilization and ground improvement for pavement construction.	Apply
CO3	Apply standard and performance-based procedures to characterize pavement materials such as aggregates, bitumen, bitumen emulsion and foamed bitumen.	Apply
CO4	Apply Indian Standard specifications to design cement concrete mixes for rigid pavements and identify suitable, sustainable, and innovative materials for pavement applications.	Apply
CO5	Design bituminous mixes using Marshall method.	Apply

iii) SYLLABUS

Relevance of subgrade soil as a pavement foundation, including soil classification, mechanical and dynamic properties, laboratory and in-situ testing, suitability for pavement layers and embankments, soil stabilization methods, and field compaction control.

Characterization of pavement construction materials such as aggregates, bitumen, bitumen emulsion, foamed bitumen, cement and cement concrete, with an introduction to performance-based material evaluation.

Bituminous pavement mixes – types, properties, mechanical performance characteristics, Marshall method of mix design, and an introduction to Superpave mix design philosophy.

Concrete mix design for rigid pavements as per Indian Standards, joint fillers and joint sealants, and an overview of special concretes used in pavement applications.

Use of sustainable and innovative materials including reclaimed asphalt pavement, cold mix and warm mix technologies, roller-compacted concrete, pervious concrete and interlocking paver blocks in pavement construction

iv) REFERENCES

1) Wright, P. H. and Dixon, K. K., *Highway Engineering*, John Wiley and Sons, 7th edition, 2004.

2) Rajib B. Mallick and Tahar El-Korchi, Pavement Engineering, CRC press, 4th edition, 2022.
3) *Manual for Construction and Supervision of Bituminous Works*, Ministry of Road Transport and Highways (MoRTH), Indian Road Congress, reprint 2008.
4) Hunter, R. N., *Bituminous Mixtures in Road Construction*, Thomas Telford Services Ltd., 1995.
5) Atkins, N. Harold, *Highway Materials, Soils and Concretes*, 4th edition, 2002, Prentice Hall.
6) Read J. And White Oak D., The Shell Bitumen Handbook, 5th edition, Shell Bitumen, Thomas Telford Publishing, London 2003.
7) Relevant IS, IRC, AASHTO and ASTM Standards.

v) COURSE PLAN

Module	Contents	No. of hours
I	Subgrade Soil Characterization: Role of subgrade in pavement performance. Types of soils used in highway construction. Soil classification systems (USCS and IS). Index properties and engineering properties of soils. Mechanical and dynamic properties of subgrade soils. Laboratory tests and in-situ testing methods for evaluating subgrade strength and stiffness. Suitability of different soils for embankments and pavement layers. Field compaction methods and quality control.	**8**
II	oil Stabilization and Ground Improvement: Need for soil stabilization. Physical and chemical methods of stabilization. Stabilization using cement, lime, calcium chloride, fly ash and bitumen. Mechanism of stabilization and factors affecting performance. Grouting: types of grouting, grout materials, grouting techniques and control. Introduction to ground improvement techniques. Applications of geotextiles and geosynthetics in pavement construction.	**8**
III	Aggregate Characterization: Types and properties of aggregates. Sampling of aggregates. Aggregate texture, shape, strength and durability. Skid resistance and polishing characteristics. Aggregate proportioning and blending: Fuller and Thompson's equation, 0.45 power maximum density graph and Superpave gradation. Bitumen sources, manufacturing processes and chemistry of bitumen.	**8**
IV	Bituminous Materials and Mix Design: Rheological characterization of bitumen – complex shear modulus and phase angle. Performance-related binder tests: MSCR and LAS (overview). Modified binders – crumb rubber, natural rubber and polymer-modified bitumen. Short-term and long-term ageing of bitumen and ageing simulation tests (RTFOT and PAV). Bitumen emulsion and foamed bitumen: properties and applications. Mechanical performance characteristics of bituminous mixes (resilient modulus, dynamic modulus, fatigue and rutting – overview). Design of bituminous mixes using Marshall method. Introduction to Superpave mix design philosophy.	**10**

V	Concrete Pavement Materials: Cement and cement concrete material characterization. IS method of cement concrete mix design for rigid pavements. Joint fillers and joint sealants for cement concrete pavements. Introduction to special concretes used in pavement applications such as roller-compacted concrete, precast concrete, pervious concrete and interlocking paver blocks. Reclaimed Asphalt Pavement (RAP): sources, processing and characterization. Recycling of bituminous pavements – hot mix recycling, warm mix recycling and cold mix recycling. Central plant recycling and in-place recycling techniques. Full Depth Reclamation (FDR) and Cold In-place Recycling (CIR). Use of foamed bitumen and bitumen emulsion in recycling applications. Cold mix and warm mix asphalt technologies. Use of industrial by-products and waste materials in pavement construction.	**11**
	Total hours	**45**

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26CE262C	Pavement Construction and Maintenance	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

The objective of this course is to know the recent developments in construction practices and modern equipment's used. This course also introduces the importance for recycling process advanced test procedures and improved mixes/layers.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Apply appropriate techniques for the construction of different layers of highway pavements	Apply
CO2	Identify suitable plants and equipment for the production and construction of highway pavement layers.	Apply
CO3	Design various components of drainage systems in highway pavements.	Apply
CO4	Make use of recycling technology for the maintenance of pavements.	Apply

iii) SYLLABUS

Construction procedures for various flexible pavement component layers and study on latest equipment used for pavement construction.

Construction of drainage systems in pavements. Cement Concrete pavement construction.

Maintenance of pavements. Concepts of reconstruction, recycling etc.

iv) REFERENCES

1) Kadiyali L. R. and Lal N. B., *Principles & Practice of Highway Engineering*, Khanna Publishers, New Delhi, 2013
2) Atkins H., *Highway Materials, Soils and Concrete,* Pearson Prentice Hall, 2002.
3) Relevant IRC codes for construction of bituminous & concrete roads.
4) Chakraborty, P. and Das, A., *Principles of Transportation Engineering*, Prentice Hall India Learning Pvt. Ltd., 2003.
5) *Manual for Construction and Supervision of Bituminous Works*, Ministry of Road Transport and Highways, IRC reprint 2008.
6) Delatte N. J., *Concrete Pavement Design, Construction and Performance*, 2nd edition, CRC Press, 2017
7) Hunter R. N., *Bituminous Mixtures in Road Construction*, Thomas Telford Services Ltd.,1995.
8) Mallick R. B., and Korchi T.E., *Pavement Engineering: Principles and Practice*, 3rd edition, CRC Press, 2017.
9) Guyer J. P., *An Introduction of Asphalt Concrete Pavement Recycling (Street and Highway Engineering)*, Createspace Independent Pub, 2014.

v) COURSE PLAN

Module	Contents	No. of hours
I	Components of road and pavement structure including subgrade, drainage system, functions, requirements and sequence of construction operations. Plants and equipment for production of materials - crushers, mixers, bituminous mixing plants, cement concrete mixers – various types, advantages and choice. Drainage – Assessment of drainage requirements for the road and design of various components, drainage materials, Construction of surface and subsurface drainage system and design of filter materials for roads. Drainage of urban roads, problems.	**9**
II	Pre-construction surveys and marking on ground. Specifications and steps for the construction of road formation in embankment and cut, construction steps for subgrade (preparation of subgrade) in cutting, filling and at grade. Construction steps for granular sub-base, quality control tests.	**9**
III	Different types of granular base course – WMM, CRM, WBM, specifications, construction method and quality control tests. Different types of bituminous layers for binder and surface courses, their specifications (as per IRC and MORTH), construction method and quality control tests. Special structural courses like stone matrix asphalt and construction of porous asphalt.	**9**
IV	Different types of sub-base and base course for cement concrete (CC) pavement and construction method. Construction of cement concrete pavements and joints, quality control during construction. Construction of special Cement concrete pavements like interlocking concrete block pavements (ICBP), Continuously reinforced cement concrete pavements (CRCP), Fibre reinforced cement concrete pavements (FRCP), white topping, Ultra thin white topping etc. General Aspects: Quality assurance, statistical approach, quality system for road construction. Safety aspects during road construction and maintenance works. Installation of various traffic safety devices and information system.	**9**
V	Road maintenance works – day to day and periodic maintenance works of various components of road works and road furniture.	**9**

	Preventive maintenance of road drainage system, pavements and other components of road. Preparation of existing pavement – patching, profile correction, Special measures to deal with reflection cracks in pavement layers, slipperiness of surface, etc. Requirements and methods for rehabilitation, recycling and re-construction.	
	Total hours	**45**

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26CE262D	Pavement Asset Management	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

This course outlines the various types of pavement distresses, its causes and remedies and the importance of pavement condition evaluation and prediction. It also includes the fundamentals and various levels of pavement management system.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Apply the deduct value method to estimate the pavement condition index.	Apply
CO2	Make use of non-destructive tests for structural evaluation of pavements.	Apply
CO3	Compare the various pavement performance prediction models.	Analyse
CO4	Select the priority of maintenance and rehabilitation actions to be carried out on highways.	Analyse

iii) SYLLABUS

Pavement management process – Concepts, levels, application of Pavement Management System.

Pavement condition data requirements – data needs, characterizing pavement performance, evaluation of structural capacity of pavements, surface distress condition, evaluation of safety

Determining present and future needs and priority programming of rehabilitation and maintenance – deterioration prediction models, determining needs, priority programming.

Rehabilitation design and economic analysis – alternate strategies of design and rehabilitation, economic evaluation of alternate pavement design strategies and selection of optimal strategies.

Application of Highway Development and Management Tool (HDM-4) in pavement management.

Implementation of Pavement Management System.

iv) REFERENCES

1) Shahin M.Y., *Pavement Management for Airports, Roads and Parking lots*, Springer, 2nd edition, 2006.
2) Haas R., Hudson W. R. and Falls L.C., *Pavement Asset Management*, Scrivener Publishing, 2015.
3) Huang Y. H., *Pavement Analysis and Design,* Prentice Hall, 2nd edition, 2004.

4) IRC: 81-1997, *Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique*, Indian Roads Congress, New Delhi, 1997.

5) IRC: 82-2015, *Code of Practice for Maintenance of Bituminous Road Surfaces*, Indian Roads Congress, New Delhi, 2015.

6) *AASHTO Guidelines for Pavement Management Systems*, American Association of State Highway and Transportation Officials, 1990 Atkins H., *Highway Materials, Soils and Concrete,* Pearson Prentice Hall, 2002.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to pavement management systems, Factors affecting pavement surface condition, Pavement distresses: Causes, Methods of measurement, Maintenance treatments. Pavement condition survey, Pavement Condition Index (PCI): Estimation of PCI by Shahin's deduct value method. Pavement surface condition: Skid resistance.	**9**
II	Characterization of roughness: Equipment for measuring roughness, profile indices, International Roughness Index (IRI). Factors affecting pavement structural condition, Structural evaluation by Non-Destructive Tests, Types–Benkelman Beam Deflection (BBD) measurement.	**9**
III	Falling Weight Deflectometer, Design of overlay using BBD data (IRC method), Destructive structural evaluation, Structural Capacity Index, Pavement performance prediction models: Mechanistic–Empirical, Regression, Stochastic, Static and Dynamic models.	**9**
IV	Pavement Management System (PMS): Concept, Objectives, Components of PMS, PMS functions, General structure. Pavement maintenance actions: Preventive and corrective maintenance, Maintenance policy. Pavement management levels: Network, Programme and Project level, Priority programming of maintenance and rehabilitation actions.	**9**
V	Life Cycle Cost (LCC) analysis, Heuristic approach: Decision matrix and decision tree based on economic evaluation and optimization. Tools for pavement management: HDM-4, Road Economics Decision model.	**9**
	Total hours	**45**

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26CE262E	Traffic Flow Theory	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

The goal of this course is to make student understand different theories of traffic flow. The concepts of queuing theory and shockwave theory for analysing traffic flow is also included.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Apply traffic modelling concept based on microscopic or macroscopic approach.	Apply
CO2	Develop empirical and analogy based models of traffic flow.	Apply
CO3	Apply the principles of queuing theory to analyse delay at intersections.	Apply
CO4	Apply shockwave theory to analyse bottleneck situations on highways.	Apply

iii) SYLLABUS

Probabilistic Analysis of Traffic Stream Characteristics.
Microscopic traffic flow models – Car following theories.
Macroscopic traffic flow models – Fluid Dynamic Models.
Transients in Traffic Flow – Shock Wave Analysis; Queuing Theory and Applications.

iv) REFERENCES

1) TRB - SR No.165 - *Traffic Flow Theory*, Transportation Research Board, Washington, 1976.
2) Gartner N. H., Rathi A. J. and Messer C. J., *Traffic Flow Theory – A Revised Monograph*, Transportation Research Board, Washington, 1997.
3) May A. D., *Traffic Flow Fundamentals*, Prentice-Hall, NJ, 1990.
4) Drew D. R., *Traffic Flow Theory and Control*, McGraw-Hill, New York, 1968.
5) *TRB: Highway Capacity Manual*, Transportation Research Board, Washington DC, 2000.
6) McShane W. R. and Roess R. P., *Traffic Engineering*, Prentice-Hall, NJ, 2010.
7) Mannering F. L. and Kilareski W.P., *Principles of Highway Engineering and Traffic Analysis*, John Wiley & Sons, 2008.
8) Neylor T.H.., *Computer Simulation Techniques*, John Wiley, 1966.
9) Gazis Denos C., *Traffic Theory*, Kluwer Academic Publishers, Norwell, MA, 2002.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction and Overview - Importance and significance of traffic flow theory Objectives of traffic systems and performance measures, Performance measures for various objectives Microscopic and Macroscopic Traffic Characteristics - Headways, Spacing, Occupancy, Speed, Density, Volume. Relationship between micro and macroscopic stream characteristics; Measures and Devices to collect traffic data; Differences between space mean and time-mean speed.	**10**
II	Probabilistic Analysis of Traffic Stream Characteristics. Basic distributions and properties Distributions of speeds, headways etc. Statistical gap acceptance models, Generation of Random Variables.	**9**
III	Microscopic traffic flow models- Car following theories Car-Following Theory, Linear and Non-linear Car Following Models-Assumptions and Results from Pipes, Forbes and GM family of car-following models; Acceleration Noise Analysis of local and asymptotic stability of traffic flow Introduction to simulation- Philosophy of Simulation Modelling, Formulation of Simulation Model.	**8**
IV	Macroscopic traffic flow models - Fluid Dynamic Models Fluid Flow Analogy Approach, Boltzman like Behaviour of Traffic Flow, First-order fluid-dynamic models - LightHill Whitham and Richards (LWR), Second-order fluid dynamic models multi-regime models, Two-fluid model.	**9**
V	Transients in Traffic Flow - Shock Wave Analysis; Time-space diagram, Accumulation diagram, Principles and Definitions Types of shockwaves arising in various traffic settings, Applications and uses of shock wave analysis; Queuing Theory and Applications Fundamentals of Queuing Theory-Definitions and Principles of queuing theory; Applications and properties of single server queues for traffic management.	**9**
	Total hours	**45**

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26CE262F	Traffic Simulation Modelling and Applications	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

Goal of this course is to give an introduction of different types of simulation, methods of random number generation, random number testing, and generation of random variates. It also gives an overview of queuing models and introduction to the various steps involved in development of traffic simulation models under heterogeneous condition.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Choose appropriate statistical models for traffic simulation.	Apply
CO2	Apply different techniques to generate random numbers for various distributions and conduct hypothesis testing.	Apply
CO3	Apply different methods to generate random variates for statistical distributions used in traffic engineering.	Apply
CO4	Make use of concepts of queuing theory and characteristics of queuing systems for measuring its performance.	Apply
CO5	Develop simulation models under homogeneous and mixed traffic conditions.	Apply

iii) SYLLABUS

Statistical models in simulation and overview of probability and statistics.

Random number generation-properties, techniques and various tests, random variate generation, various techniques and methods for generation. Queueing Theory and models- Concepts and characteristics of queueing systems.

Simulation in traffic engineering- Application of traffic simulation models, simulation of queueing models, discrete simulation models.

iv) REFERENCES

1) Law M. A. and Kelton W. D., *Simulation Modeling and Analysis*, McGraw Hill Higher Education, 3rd edition, 2000
2) Deo, N., *System Simulation by Digital Computer*, Prentice Hall India, 1978.
3) Drew D.R., *Traffic Flow Theory and Control*, McGraw Hill, 1968.
4) May A. D., *Traffic Flow Fundamentals*, Pearson, 1990.
5) Ross S. M., *Simulation*, Elsevier, 5th edition, 2013.
6) Dowling R., Skabardonis A. and Alexiadis V., Traffic *Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software*, Federal Highway Administration, 2004.

7) Roess R., Prassas, E. and McShane, W., *Traffic Engineering*, 5th edition, Pearson, 2019.
8) Washington S., Karlaftis M. and Mannering F., *Statistical and Econometric Methods for Transportation Data Analysis*, Chapman & Hall/CRC, 2020.
9) Henderson S., and Nelson B., *Handbooks in Operations Research and Management Science*, Elsevier, 1st edition, 2006.
10) Chung C. A*., Simulation Modeling Handbook,* CRC Press, 1st edition, 2019.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to traffic simulation - Definitions, advantages and disadvantages, different types, simulation languages. Statistical models in simulation - discrete distribution, continuous distribution.	**9**
II	Monte Carlo techniques, stochastic simulations. Random Number Generation: Properties of random numbers, generation of true and pseudo random numbers, techniques for generating random numbers. Hypothesis testing, various tests for uniformity (Kolmogorov- Smirnov and Chi-Square) and independence (runs, autocorrelation, gap, poker).	**9**
III	Random Variate Generation: Different techniques to generate random variate- inverse transform technique, direct transformation technique, convolution method and acceptance rejection techniques, algorithms for generation of random variates for different distributions.	**9**
IV	Queueing Models: Queueing theory concepts, characteristics of queueing systems, queueing notations, measures of performance of queueing systems. Steady state behaviour of Markovian models (M/G/1, M/M/1, M/M/c). Simulation in Traffic Engineering: Application of traffic simulation models for analysis of dynamic traffic systems and design - input data preparation, calibration, validation, analysis of output.	**9**
V	Models for vehicle arrival and related models - development of simulation models for mid-block and intersections under homogenous and mixed traffic. Simulation of queueing models using relevant software. Discrete simulation models: Cellular automata concepts, discretization of time and space, rules for acceleration, deceleration, randomization, and vehicle updation, examples. Introduction to Vissim software and its applications.	**9**
	Total hours	**45**

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26CE262G	Transportation Network Analysis	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

The goal of this course is to introduce the basic concepts of transportation network analysis and to explore some of its applications. The focus of analysis of transportation networks are on a larger area, such as a city or metropolitan region, rather than on a specific intersection or roadway**.**

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Apply network flow concepts in various traffic engineering applications.	Apply
CO2	Model complex transportation network optimization and equilibrium problems using mathematical programming.	Apply
CO3	Identify appropriate solutions for transportation network optimization and equilibrium problems.	Apply
CO4	Model a variety of transportation planning problems as network models.	Apply

iii) SYLLABUS

Network flows – Applications, definitions;

Shortest Path Algorithms – Label setting, Dijkstra's and Dial's algorithms, optimality conditions;

Minimum cost network assignment – optimality conditions; Network equilibrium analysis; principles and optimization formulations, Applications – Applications of min-cost, max- flow, and shortest path algorithms to transportation and infrastructure networks.

iv) REFERENCES

1) Boyles S. D., Lownes N. E. and Unnikrishnan A. Lida, Y., *Transportation Network Analysis*, Version 0.89 (Public beta), 2021.
2) Ahuja, R., Magnanti, T.L., and Orlin, J.B., *Network Flows: Theory, Algorithms and Application*, Prentice Hall, New Jersey, 1993.
3) Bell, M.G.H., and Lida, Y., *Transportation Network Analysis*, Wiley Publishers, 1997.
4) Sheffi, Y. *Urban transportation networks: Equilibrium analysis with mathematical programming methods*, Prentice Hall Inc., 1985.

v) COURSE PLAN

Module	Contents	No. of hours
I	Network flows: Applications, definitions, graphs, paths, trees, cycles, loops, walk, network representation (adjacency list and matrices) and basic network transformations; Network algorithms; Complexity, Search Algorithms, Strategies for designing polynomial algorithms.	**9**
II	Shortest Path Algorithms: Label setting, Dijkstra's and Dial's algorithms, Optimality conditions, label correcting algorithms and optimality conditions, detecting negative cycles, all-pair shortest path algorithms; pre-flow push polynomial time algorithms, capacity scaling techniques.	**10**
III	Minimum cost network assignment: optimality conditions, cycle-canceling algorithm, Successive shortest path algorithm, other polynomial time variants.	**7**
IV	Definitions of network equilibrium – mathematical formulation of traffic equilibrium - User Equilibrium, System Optimal and Stochastic User Equilibrium - equilibrium between modes. Network equilibrium analysis; principles and optimisation formulations, Frank-Wolfe algorithm; Special cases and variants.	**10**
V	Applications: Applications of min-cost, max-flow, and shortest path algorithms to transportation and infrastructure networks: transportation networks, airline, freight, facility location, logistics, network design. Introduction to Computer Software: Principles of TRIPS, EMME, CUBE, Demo Versions, Case studies	**9**
	Total hours	**45**

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26CE262H	Road Safety Management	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

Goal of this course is to introduce the concepts of road safety management system, road safety-based design techniques, methods of road safety audit and crash mitigation measures.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Develop a road safety management system after identification of causative factors.	Apply
CO2	Model crash data using statistical techniques.	Apply
CO3	Examine the safety of a highway system by conducting a road safety audit.	Analyse
CO4	Apply suitable techniques for crash reconstruction using the data collected.	Apply
CO5	Make use of guidelines prescribed in the manual for road safety audit to assess the safety performance of a highway system.	Apply

iii) SYLLABUS

Road safety scenario, causes of road crashes, road safety management system.
Sources of crash data, representation and modelling of crash data.
Road safety audit-overview, stages, checklists, reporting, case studies.
Crash Reconstruction-theory involves, case studies, speed management, 4E's of road safety.
Highway safety during construction, Geometric design for safety, Blackspot -severity level and identification techniques

iv) REFERENCES

1) Ezra Hauer, *Observational Before-After Studies in Road Safety*, Pergamon Press, 1997 (reprinted 2002).
2) Institute of Transportation Engineers (ITE), *The Traffic Safety Toolbox: A Primer on Traffic Safety*, ITE, 1999.
3) J. Stannard Baker, *Traffic Collision Investigation*, Northwestern University Center for Public Safety, 2002.
4) Leonard Evans, *Traffic Safety*, Science Serving Society, 2004.
5) Lynn B. Fricke, *Traffic Accident Reconstruction*, Northwestern University Center for Public Safety, 1990.
6) Ogden K.W., *Safer Roads: A Guide to Road Safety Engineering*, Avebury Technical, 1996.

7) Popkess C.A, *Traffic Control and Road Accident Prevention*, Chapman and Hall, 1997
8) Rune Elvik and Truls Vaa, *The Handbook of Road Safety Measures*, Elsevier, 2009.
9) Simon Washington, Matthew Karlaftis, and Fred Mannering, *Statistical and Econometric Methods for Transportation Data Analysis*, Chapman & Hall/CRC Press, 2003.
10) M. N. Shreehari, K. V. Ramesh, *National Conference on Traffic Engineering and Road Safety in India: Problems & Prospects*, Traffic Engineers & Safety Trainers, 2004.
11) Martin Belcher, Steve Proctor, Phil Cook, *Practical Road Safety Auditing*, I C E Publishing, 2015
12) Becky P. Y. Loo, Tessa Kate Anderson, *Spatial Analysis Methods of Road Traffic Collisions*, CRC Press, 2015.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to road safety: Road safety scenario at the global level and in the Indian context. Causes of road Crashes-Human characteristics and vehicular characteristics. Road Safety Management System: Safe systems approach—guiding principles, traditional versus safe systems approach, components, implementation. Multi-causal dynamic systems approach to safety, crash vs accident, road safety improvement strategies, elements of a road safety plan, Safety Data Needs.	**8**
II	Crash data- Sources of data-primary and secondary, integrated road accident database (IRAD), data collection system-traditional and modern methods Crash data representation and modelling- Collision and Condition diagrams, Prediction models, Severity models, Modelling approaches- statistical and soft computing methods.	**8**
III	Road Safety Audits: Road Safety Audit: An Overview, Stages in audit, conducting a Road Safety Audit - the key steps, managing road safety audit, road safety audit checklists, practices for safer roads, safety audit case studies and reporting, proactive and reactive approaches.	**10**
IV	Crash Reconstruction: Accident statistics, Collinear and Angular Collision, Poisson Impact theory and Energy Theory. Crash Mitigation: Evidence based approach, interventions, Case studies, Speed management, factors influencing speed, Measures for speed Management-Speed zonings and Speed limits, Engineering Enforcement, Education, Emergency care.	**9**
V	Highway safety measures during construction, Highway geometry and safety, Geometric design consistency and safety. Blackspot- definition, severity levels of crashes, blackspot identification techniques –crash frequency, fatal crash frequency, equivalent property damage only, upper tail critical test.	**9**
	Total hours	**45**

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26CE262I	Multimodal Transit Systems	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

The goal of this course is to introduce the concepts of Travel demand management and sustainable principles in planning, operation and management of urban public transit systems. It also gives an overview of Intelligent Transportation systems and non- motorized urban transport.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Apply the concepts of vehicular level of service for measuring the performance of a given transit system.	Apply
CO2	Apply standard procedures for the planning of NMT systems.	Apply
CO3	Estimate the level of service of bicycle and pedestrian facilities of a given roadway.	Apply
CO4	Estimate the multimodal level of service for the design of multimodal transfer facilities for a given road network.	Apply

iii) SYLLABUS

Urbanization and transport, key issues in urban transportation, challenges in urban transportation, travel demand modelling overview.

Introduction to public transportation – basic operating elements of public transportation, bus transportation, intermediate public transportation, public transportation, bus rail transit capacity, transit stop.

Non- Motorised Transportation (NMT) planning, basic NMT characteristics, pedestrian level of service (PLOS) based on flow models.

Bicycle facilities and level of service (BLOS), and bicycle compatibility index (BCI). Sustainable strategies for urban transportation.

iv) REFERENCES

1) G Sammer and W. Saleh, *Travel Demand Management and Road User Pricing: Success, Failure and Feasibility*, AshGate 2009.
2) S. Ison and T. Rye, *The Implementation and Effectiveness of Transport Demand Management Measures - An International Perspective*, Ashgate, 2008.
3) R. Tolley, *Sustainable Transport: Planning for Walking and Cycling in Urban Environment*, Woodhead Publishing Ltd., 2003.
4) Fruin J. J. , *Pedestrian Planning and Design*, McGraw Hill Publication, 1987.
5) Hudson M., *The Bicycle Planning*, Open Books, 1982.

6) M. A. Chowdhury and A. W. Sadek, *Fundamentals of Intelligent Transportation Systems Planning*, Artech House, Inc. Boston, 2003.
7) J. M. Sussman,*Perspectives on Intelligent Transportation Systems (ITS)*, MIT, Springer, 2008.
8) Ceder, A., *Public Transit Planning and Operation: Modeling, Practice and Behavior*, 2nd edition, CRC Press, 2016.
9) Garber N. J. and Hoel L. A., *Traffic & Highway Engineering*, 5th edition, Cengage Learning, 2015.
10) IRC 103:2012, *Design of Pedestrian Facilities*, Indian Road Congress, New Delhi, 2012.
11) IRC 11: 2015, *Design and Layout of Cycle Tracks,* Indian Road Congress, New Delhi, 2015.
12) Indo-Highway Capacity Manual (HCM)-2018, CSIR-CRRI, New Delhi.
13) *Transit Oriented Development Guidance* Document, Sustainable Urban Transportation Project, Ministry of Urban Development, Government of India, 2016.
14) *NMT Guidance Documen*t, Sustainable Urban Transportation Project, Ministry of Urban Development, Government of India, 2016.
15) Public Bicycle Sharing Guidance Document, Sustainable Urban Transportation Project, Ministry of Urban Development, Government of India, 2016.

v) COURSE PLAN

Module	Contents	No. of hours
I	Overview of urban Transportation-Urbanization and Transport, Key issues and Challenges, Travel demand modelling overview, Vehicular Level of Service (LOS) overview. Public Transportation-Introduction, basic operating elements, Bus Transportation, Financing public transportation, Transit marketing, Rail transportation, Intermediate Public Transportation, Measuring performance of transit systems.	**9**
II	Advanced operation concepts of public transportation, Bus and Rail Transit Capacity, Station Capacity, Transit Stop Location. Introduction to NMT Systems, Data collection and analysis in NMT Planning, complementarity and selection of interventions, Alternative Selection through Economic & Financial Analysis, Basic NMT Characteristics.	**9**
III	Pedestrian Data Collection and Flow Characteristics, PTS Case Studies, Pedestrian flow characteristics on facilities, Pedestrian Level of Service (PLOS) based on Flow models, Other types of Pedestrian Level of Service, HCM 2010	**9**

IV	Travel Demand Management overview, Push measures cases, Pull measure cases Parking Studies, Transit Oriented Development (TOD), Introduction to Intelligent Transportation Systems, ITS components, applications and communication, ITS Architecture Electronic Toll Collection, Public Bicycle Sharing (PBS) System with ITS.	**9**
V	Types of Transit Modes - Buses - LRT, RTS - Air cushioned and Maglev System, Dual Mode Buses, Para Transit - Dial - a - Ride - Taxi- Jitney and Ride sharing – PRT Networks –DRTS Technological Characteristics - Resistances, acceleration & velocity Profiles – Operational characteristics speed, capacity & payloads - Route capacity – Comfort conditions - Performance relationships - Public and Private Operations - Modes for Intercity Transport. Mulltimodal Level of Service (MMLOS), Design of multimodal transfer facilities, Park & Ride.	**9**
	Total hours	**45**

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26CE262J	Geoinformatics in Transportation Engineering	PECP	2	0	2	3	2026

i) COURSE OBJECTIVES

This course introduces the basic concepts of Geoinformatics in the context of transportation planning, traffic engineering, and transportation system management. It also involves database development for doing transportation analysis in GIS environment.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Apply geospatial data models, coordinate systems, and projection concepts for organizing and managing transportation-related spatial data.	Apply
CO2	Apply geometric transformation and data quality assessment techniques for preparing reliable and accurate GIS databases.	Apply
CO3	Apply spatial and attribute data analysis techniques using vector and raster tools to generate thematic maps and decision-support outputs.	Apply
CO4	Apply GIS-based analytical tools for transportation planning tasks.	Apply
CO5	Use GIS software tools to develop, visualize, and interpret transportation engineering solutions.	Apply

iii) SYLLABUS

Introduction to geospatial data, data models, components of GIS, applications.

Transportation Planning using GIS, Traffic Analysis Zone (TAZ) and screen lines, Four Stage Planning Process, Network representation of a transportation System, origin–destination analysis and accessibility concepts.

Introduction to Intelligent Transport System, Public Transportation Management System, multimodal transportation analysis and decision support using GIS

Application of GIS in vehicle routing analysis and traffic operations, safety and sustainability studies, visualizations of traffic data in GIS, Travel time analysis using GPS-GIS integration and emerging probe-based data sources.

GIS-T applications – scope of TransCAD and EMME in Transportation Planning along with exposure to open-source and Web GIS platforms and selected case studies.

iv) REFERENCES

1. Kang-Tsung Chang, *Introduction to Geographic Information Systems,* Tata McGraw Hill Publishing Company Ltd, New Delhi, 2008.
2. Lo C.P. & Yeung A.K.W., *Concepts and Techniques of Geographic Information Systems*, Pearson; 2nd edition, 2006.
3. Thill Jean-Claude, *Geographical Information Systems in Transportation Research,* Pergamon, 2000.

4. Peter A. Burrough and Rachael A. McDonnell, *Principles of Geographical Information Systems,* Oxford University Press, 2005
5. Clarke, K., *Getting Started with Geographic Information Systems,* Pearson; 5th edition, 2010.
6. Geo Information Systems – *Applications of GIS and Related Spatial Information Technologies,* ASTER Publication Co., Chestern (England), 1992
7. Scholten & Stillwen , GIS for Urban & Regional Planning, Kulwer Academic Publisher. 1990.
8. P. A.Longley, M.F. Goodchild, D.J. Manguire, D.W. Rhino, Geographical Information System, Volume I: Principal and Technical Issues, John Wiley & Sons, 1999.
9. P.A. Longley, M.F. Goodchild, D.J. Manguire, D.W. Rhino, Geographical Information System: Volume II: Management Issues and Applications, John Wiley & Son, 2005.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to geospatial data, map projection and coordinate systems. Data models: Topological and non-topological vector data, topology rules, georelational data model, object-based data model (interface, encapsulation, inheritance, polymorphism). Data models for composite features: TIN, region and routes. Raster data model – nature and elements, types, data storage, data compression, data conversion.	**6**
	Lab Exercises: i) Coordinate System and Projection ii) Vector Data Creation and Topology iii) Raster Data Handling iv) TIN Model, Create TIN from contour data, Generate slope and elevation visualization.	**6**
II	Geometric transformation – map-to-map and image-to-map transformations, transformation methods, affine transformation, RMS error, resampling, pyramiding. Geospatial data quality and standards: accuracy, precision, errors, uncertainty, assessment. Spatial data editing errors – topological and non-topological editing. Attribute data input and management – relational model, normalization, relationships, attribute entry.	**6**
	Lab Exercises: i) Georeferencing Georeferenced scanned map, Use GCPs, Compute RMS error, Compare different transformation methods. ii) Resampling Techniques Apply nearest neighbor, bilinear, and cubic, Compare outputs visually and statistically. iii) Attribute Table Creation Create road inventory table, Add fields, Perform attribute query. iv) Data Quality Assessment	**6**

III	Data exploration – descriptive statistics, graphics, attribute and spatial query, map manipulation. Vector data analysis – buffering, overlay, slivers, distance measurement, pattern analysis. Raster data analysis – local operations (reclassification), neighborhood operations, zonal operations, physical distance measurement.	**6**
	Lab Exercises: i) Buffer Analysis Create 500 m buffer around bus stops, Estimate service coverage area. ii) Overlay Analysis Overlay land use and road network, Identify commercial zones along major roads. iii) Spatial Query Select roads within 200 m of schools, Generate statistics. iv) Raster Suitability Analysis Reclassify slope, Perform zonal statistics. v) Distance Analysis Compare Euclidean vs network distance.	**6**
IV	Application of GIS in Transportation Planning: Urban planning, TAZ and screen lines, Four Stage Planning Process (brief), network representation, shortest path determination. GIS-based transportation planning, spatial and non-spatial data. OD matrix development, accessibility and mobility analysis, multimodal network analysis, LUTI. Transit-Oriented Development (TOD). Intelligent information system for road accessibility study, terminal location, DSS for land use planning, aerial photography and satellite imagery applications.	**6**
	Lab Exercises: i) Traffic Analysis Zone (TAZ) Creation ii) OD Matrix Visualization iii) Shortest Path Analysis iv) Accessibility Analysis	**6**
V	Application of GIS in Highway and Traffic Engineering: Highway alignment planning, congestion analysis, accident investigation, LOS mapping, route optimization, bus route rationalization, utility management. Traffic safety and sustainability applications (NMT, EV charging infrastructure). Vehicle routing analysis, traffic data visualization. Integration of GPS and GIS, travel time analysis. GIS-T applications: Scope of TransCAD and EMME (introduction), exposure to open-source GIS tools, Web GIS platforms, case studies.	**6**
	Lab Exercises: i) Highway Alignment Suitability ii) Traffic Congestion Mapping iii) Accident Hotspot Mapping iv) EV Charging Station Suitability	**6**
	Total hours	**60**

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26CE262K	Analytical Techniques in Transportation Planning	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

The goal of this course is to introduce the concepts of multivariate data analysis technique, network flow theory, econometric models and its application in transportation problems.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Apply various data analysis techniques for analyzing problems in traffic and transportation planning.	Apply
CO2	Apply network transformation algorithms for solving a given transportation network problem.	Apply
CO3	Apply the concepts of latent variable modelling for a given transportation planning problem.	Apply
CO4	Apply the concepts of discrete outcome modelling for a given transportation network problem.	Apply

iii) SYLLABUS

Multivariate data analysis techniques- data, estimation of centroid, standard deviation, factor analysis, cross classification procedure, applications.

Network Flow Theory- basic concepts and definitions, forward and reverse star representations, network transformations, applications.

Econometric models, latent variable models, structural equation modelling, duration models, discrete outcome models.

iv) REFERENCES

1) R. K. Ahuja, Thomas L. Magnanti, J. B. Orlin, *Network Flows: Theory, Algorithms and Applications*, 1st edition, Prentice Hall, 2015.
2) Juan de Dios Ortúzar, Luis G. Willumsen, *Modelling transport*, 4th edition, Wiley Publications, 2011
3) Kalyanmoy Deb, *Muliti-Objective using Evolutionary Algorithms*, 1st edition, Wiley Publications, 2001.
4) Simon Washington, Matthew G. Karlaftis, Fred Mannering, Panagiotis Anastasopoulos, *Statistical and Econometric Methods for Transportation Data Analysis*, 3rd edition, CRC Press LLC, 2020.
5) Cooley, W. W. und P. R. Lohnes: Multivariate data analysis. J. Wiley and Sons Inc., New York 1971
6) Alan Wilson, *Entropy in Urban and Regional Modelling (Routledge Revivals)*, Routledge, 2013.
7) Adib K. Kanafani, *Transportation Demand Analysis*, McGraw – Hill, 1983.

v) COURSE PLAN

Module	Contents	No. of hours
I	Types of data, basic vectors and matrices, Sample Estimation of centroid, Standard deviation, Dispersion, Variance and Covariance, Correlation matrices, Principle component, Factor Analysis, Cluster Analysis, Cross Classification procedure in Multivariate data analysis, Application to problems in traffic and Transportation Planning.	**10**
II	Basic Concepts and definitions – directed and undirected graphs-nodelinks -trees-path-cycles-connectivity – cut, network representation - Node-arc incidence Matrix, Node-Node adjacency Matrix- adjacency Lists- forward and reverse star representations.	**9**
III	Network transformations- berth and search algorithms- formulation of shortest path problem- maximum flow problem- minimum cost flow problem- algorithm- applications in transportation network problem .	**9**
IV	Latent Variable Models – Structural Equation modelling – Duration models – Hazard based duration models – Non parametric, semi parametric and fully parametric models .	**9**
V	Discrete outcome models – Multinomial Logit Models – Nested Logic Models – Discrete Continuous models (Overview Only).	**8**
	Total hours	**45**

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26CE262L	Green Transportation Systems	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

The goal of this course is to introduce the concepts of sustainable planning and design and thereby suggest sustainable solutions for transportation related problems. It also outlines the procedure for Environmental impact assessment of transportation projects.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO 1	Make use of sustainable transportation planning principles for development of sustainable transportation networks.	Apply
CO 2	Identify the transportation needs of special populations.	Apply
CO 3	Assess the environmental impacts of transport related projects.	Apply
CO 4	Apply the concepts of sustainable transportation for retro fitting existing urban areas for reducing congestion and emissions.	Apply

iii) SYLLABUS

Introduction to the concept of sustainability, basic principles, sustainable transportation planning, land use and travel behaviours, networks, automobile dependence and impacts, design for sustainable transportation, vulnerable road users, professional praxis and paradigm shift, innovations, case studies, emerging concepts, congestion and pollution management, sustainability through public transport, EIA of Transportation Projects.

iv) REFERENCES

1) Mc Clintock, H., Planning for Cycling: Principles, Practice and Solutions for Urban Planners, CRC Press, 1st edition, 2002.
2) Frumkin, H., Frank, L. and Jackson, R.J., Urban Sprawl and Public Health, designing, planning, and Building for Healthy Communities, Island Press, 1st edition, 2013.
3) Newman, P. and Kenworth, J. Sustainability and Cities – Overcoming Automobile Dependence, Island Press, 2013.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction: Sustainable transportation, definition, necessity, fundamental principles, quantifying sustainability. Sustainable	9

	transportation planning: land use and travel behaviour; Sustainable Transportation Networks; built environment and public health; transportation demand management. Automobile dependence and oil consumption; the transportation needs of special populations (elderly, children, disabled and immigrants)	
II	Design for Sustainable Transportation: design of bicycle and pedestrian facilities; safety issues for pedestrians and bicyclists; Bicycle and pedestrian planning, Professional praxis; principles of applying professional praxis under a state of paradigm shift	**9**
III	Environmental Impact Assessment For Transportation Projects: Basic Concepts, Objectives, Transportation Related Environmental Impacts – Vehicular Impacts – Safety & Capacity impacts– Roadway Impacts – Construction Impacts, Environmental Impact Assessment – Environmental Impact Statement, Environment Audit, Typical case studies.	**9**
IV	Retro fitting existing urban areas; Innovative transportation solutions, case studies. Paradigm shift in planning, Emerging concepts in sustainable transportation: green vehicles and green roads, green and alternate fuels; managing congestion: car- sharing, pricing control: congestion and emission pricing.	**9**
V	Sustainable public transport: promoting public transport: principles involved and techniques, miscellaneous transportation systems, integrated public transport systems	**9**
	Total hours	**45**

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26CE262M	Advanced Optimization Techniques for Transportation Engineering	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

It aims at introducing the use of quantitative methods and techniques for effective decision making; model formulation and applications that are used in solving decision making problems related to transportation engineering. It also provides proficiency with tools in optimization including fundamental applications of these tools in contexts involving uncertainty and scarce or expensive resources.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO 1	Apply the concepts of probability and statistics for taking management decisions.	Apply
CO 2	Apply techniques of dynamic programming and reliability in traffic and pavement management systems.	Apply
CO 3	Apply the concept of game theory for network flow analysis.	Apply
CO 4	Assess the trends and characteristic moments for a given time series model.	Apply

iii) SYLLABUS

Concept of uncertainty – Markov analysis, stochastic random process, Dynamic programming approach – applications.

Game theory – solving mixed strategy game; Replacement models.

Fundamentals of network flow theory – shortest route problems – solution of maximum flow model – formulation of CPM-PERT Network.

Time series models – Forecasting models, measurement of trends.

Classical optimization – Optimal problem formulation, Multi criteria mathematical programming problems, Applications of optimization in traffic and pavement management.

iv) REFERENCES

1) K. Sharma., *Operations Research Theory & Applications*, 3rd edition, Macmillan India Ltd, 2007.
2) P. K. Gupta and D.S. Hira, *Operations Research*, S. Chand & Co., 2007.
3) J K Sharma., *Operations Research, Problems and Solutions*, 3rd edition, Macmillan India Ltd.

4) N. V. S. Raju, *Operations Research*, HI-TECH, 2002

v) COURSE PLAN

Module	Contents	No. of hours
I	Probability and statistical analysis for management decisions. Concept of uncertainty-Markov analysis–stochastic random process-transition probability-Markov chain-steady state condition.	**9**
II	Brief introduction to linear programming, Dynamic programming and reliability. Characteristics of dynamic programming. Dynamic programming approach applications in traffic and pavement management-smothering, capital budgeting, Stage Coach/Shortest Path, and Reliability problems-formulation	**9**
III	Basics of Game theory. Concept-Two person zero-sum game-pure and mixed strategy-Games-saddle point-Odds method-Dominance Method and graphical method for solving mixed strategy game.	**9**
IV	Replacement Models - Deteriorating items with increasing maintenance cost and constant money value – Items that fail suddenly –Replacement policy: individual and group. Fundamentals of network flow theory	**9**
V	Network representation- Minimal spanning tree algorithm- shortest route problems-Maximum flow model-linear programming-excel spreadsheet solution of maximum flow model-minimum cost capacitated flow problems- formulation (LPP)-capacitated network simplex algorithm-LPP formulation of CPM-PERT Network. Time series models: Forecasting models-introduction to time series models-characteristics moments in a time series- measurement of trends- ARMA-ARIMA	**9**
	Total hours	**45**

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26CE262N	Economic Appraisal of Projects	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

The goal of this course is to identify various costs and benefits associated with highway construction, fare policy for bus transit, pricing theory and congestion pricing. It also introduces the various methods of economic analysis and stages of project appraisal and feasibility report preparation.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO 1	Apply the concepts of demand and supply of transport for identification and measurements of transportation costs and benefits.	Apply
CO 2	Assess the cost and benefit associated with transport projects for economic and financial appraisal in the preparation of feasibility report.	Analyse
CO 3	Identify the appropriate method of economic evaluation for a given transportation project.	Apply
CO 4	Apply standard procedures for economic evaluation of mass transit projects.	Apply

iii) SYLLABUS

Demand and supply of transport, elasticity of demand and supply concepts, costs and benefits identification and measurements of transportation costs and benefits. Accident cost, congestion cost and pricing, consumers' surplus and social surplus criteria, fare policy for bus transit. Econometrics and project appraisal, social cost benefit analysis, economic and financial appraisal, financing transport infrastructure, preparation of projects, feasibility reports, economic analysis, indirect cost and benefits of transportation projects, economic evaluation of mass transit projects.

iv) REFERENCES

1) K. Sharma., *Operations Research Theory & Applications*, 3rd edition, Macmillan India Ltd, 2007. Cole, S., Applied Transport Economics: Policy Management and Decision Making, Kogan Page India, 3rd edition, 2010.
2) Gwilliam, K. M. and Mackie,P.J., Economics and Transport Policy, Routledge Library Editions, 1st edition, 2017.
3) Kadiyali,L. R., Traffic Engineering and Transport Planning, Khanna publishers, 8thedition, 2013.
4) Mohring,H.T. , Transportation Economics, Harper Collins Distribution Services, 1976.
5) Sabratore,D., Theory and problems of microeconomic theory, McGraw Hill Education,2017.

6) Button,K., Transport Economics, Edward Elgar Publishing Ltd, 3rd edition 2010.
7) Sarkar,P. K., Maitri, V. and Joshi,G. J.,Transportation Planning, Kindle Edition, PHLearning, 2014.
8) P. K. Gupta and D.S. Hira, *Operations Research*, S. Chand & Co., 2007.
9) Maitri, V. and Sarkar, P. K., Theory and Application of Economics in Highway and Transport Planning, Standard Publishers, 2 nd edition, 2017.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction, significance of transport, demand and supply of transport, Elasticity of demand and supply concepts and principles of highway engineering economy. Costs and Benefits, Identification and measurements of transportation costs and benefits, Capital cost, Inflation cost, Interest during construction, Maintenance cost, Road user costs, Fixed and operating costs. Accident cost, Methodology for monetary evaluation of passenger's travel time, Value of increased comfort and convenience.	**9**
II	Congestion cost and pricing, Consumer's surplus and social surplus criteria, Fare policy for bus transit. Econometrics & Project Appraisal, Econometrics of industrial location, Project Appraisal-Technical Appraisal, Social Appraisal-Social Cost Benefit analysis, Economic and financial appraisal.	**9**
III	Financing transport infrastructure - Appraisal through financial statement, Taxation, and Toll collection. Preparation of projects, Feasibility reports.	**9**
IV	Interest and Economic Analysis Compound interest equations, discount cash flow, Method of economic evaluation-Rate of return, Net present value. Internal rate of' return method, First year rate of return, Present worth of cost, EUAC, Benefit cost ratio.	**9**
V	Indirect costs and benefits of transportation projects, Comparison of various methods of economics analysis, case studies and problems, Economic evaluation of mass transit projects.	**9**
	Total hours	**45**

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26CE062A	Data Science and ML in Civil Engineering	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

Goal of this course is to introduce the applications of Artificial Intelligence (AI) in Civil Engineering by covering foundational concepts of artificial intelligence and machine learning techniques, with a focus on real-world applications, while the project component enhances practical skills to solve domain-specific challenges using AI, and to obtain comprehensive knowledge of various tools and techniques for data transformation and visualization, to learn probability and probabilistic models of data science, and to learn basic statistics and hypothesis testing for specific problems

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO 1	Apply exploratory data analysis and create insightful visualisations to identify patterns	Apply
CO 2	Make use of statistical foundations of data science and analyse the degree of certainty of predictions using statistical test and models	Analyse
CO 3	Apply the basic probability principles and techniques in data science	Apply
CO 4	Apply Machine learning techniques in solving problems in Civil Engineering.	Apply

iii) SYLLABUS

Data Science process, Memorization methods, Unsupervised models, Univariate data exploration, Data visualisation, Prediction and filtering, Probability theory and Statistics, Machine Learning Basics.

iv) REFERENCES

1) Russell, S., & Norvig, P. Artificial Intelligence: A Modern Approach, 4th Edition, Pearson Education, 2022
2) Alpaydin, E. Introduction to Machine Learning, 4th Edition, MIT Press, 2020.
3) Mandal, U. K., & Saha, S. AI and Data Analytics in Civil Engineering, 1st edition, CRC Press, 2023.
4) Nathan Yau, "Visualize This: The Flowing Data Guide to Design, Visualization and Statistics", Wiley, 2011
5) Nina Zumel, John Mount "Practical Data Science with R··. Manning Publications. 2014

v) COURSE PLAN

Module	Contents	No. of hours
I	Data Science process - Roles and stages in a data science project, working with files and databases, Exploring and managing data. Exploratory Data Analysis. Exploring Univariate Data - Histograms - Stem-and Leaf Quantile Based Plots - Continuous Distributions - Quantile Plots- QQ Plot- Box Plots.	9
II	Probability Concepts -Axioms of Probability - Conditional Probability and Independence - Bayes Theorem - Expectation - Mean and Variance Skewness Kurtosis; Common Distributions-Binomial, Poisson, Uniform, Normal, Exponential	9
III	Introduction to Statistics - Sampling, Sample Means and Sample variance sample moments, covariance, correlation, Sampling Distributions - Parameter Estimation Bias - Mean Squared Error - Relative Efficiency - Standard Error - Maximum Likelihood Estimation. Comparing Two Samples - A/B Testing - ANOVA.	9
IV	Introduction to Machine Learning: Basics of Machine Learning (ML)-types of Machine Learning Systems and Challenges. Supervised learning- Regression techniques- Linear Regression, Logistic regression, Multiple linear regression; Polynomial Regression (concept only), Decision Tree Regression (concept only). Classification techniques (Basic concept only)- Support Vector Machines. Application in prediction..	9
V	Unsupervised learning-Dimensionality Reduction – Need, Principal Component Analysis, Clustering: Basic concepts, Types of Clustering, similarity/dissimilarity measures. Clustering Algorithm-K-means algorithm, Hierarchical clustering (concepts only), Density-based clustering (concept only). Performance Evaluation Measures – clustering. Relevant Case studies.	9
	Total hours	**45**

2. SYLLABI FOR VARIOUS COURSES

(c) INDUSTRY ELECTIVE COURSE

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26CE266A	Highway Asset Management	IEC	3	0	0	3	2026

i) COURSE OBJECTIVES

The goal of this course is to introduce the students to industry practices on the management of highway assets. The course will give in-depth information on the various aspects of pavement evaluation, maintenance and management, regarding Indian conditions. The course also deals with the various safety standards in the highway construction industry.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Explain the standards and specifications pertaining to highway assets.	Understand
CO2	Apply standard procedures to evaluate the structural and functional condition of pavements.	Apply
CO3	Explain the concepts of pavement management system.	Understand
CO4	Develop maintenance strategies for highways.	Apply
CO5	Undertake project planning and monitoring.	Apply

iii) SYLLABUS

Highway asset management, pavement asset management

Pavement management system

Pavement evaluation and maintenance

Bidding, contract preparation, planning, project monitoring and quality control

Safety in highway projects

iv) REFERENCES

1) Ralph C.G. Haas, W.Ronald Hudson, Pavement Management Systems, McGraw-Hill Inc., US, 1978.

2) Ralph C. G. Haas, W. Ronald Hudson, John P. Zaniewski, Modern Pavement Management, Krieger Publications, New York, 1992.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Highway Asset Management: Brief overview of highway assets, Importance of highway assets on a regular day-to-day highway operations, standards and specifications pertaining to highway assets.	**9**
II	Pavement Asset Management: Pavement investigations, Structural evaluation, Functional evaluation, Data analysis of FWD and NSV, Estimation of structural capacity and functional capacity of highways based on the investigations data, Introduction to Pavement Management System (PMS).	**9**
III	Pavement Maintenance: Routine maintenance techniques and technologies, Preventive maintenance techniques and technologies, Major maintenance techniques and technologies, Hands-on experience in preparation of strategy using data from Indian highways.	**10**
IV	Major Maintenance execution: Planning of major maintenance, Bidding procedure, Contract preparation, Machinery and manpower planning, Project monitoring, Quality control by statistical methods, Hand-on experience in project planning and monitoring. Introduction to HDM-4.	**9**
V	Safety during highway maintenance: Safety in the construction industry, Safety measures, Safety programmes, Safety awareness and implementation of safety plan, Current safety standards in India, Improvements in safety standards required for Indian conditions.	**8**
	Total hours	**45**

2. SYLLABI FOR VARIOUS COURSES

(d) AUDIT COURSE

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26MC061A	Research Methodology and IPR	AC	2	0	0	0	2026

i) COURSE OBJECTIVES

This course is intended to prepare the M. Tech students to carry out their dissertation/ research project work effectively, with a research bias. The student will be able to formulate a viable research problem, do a critical analysis of publications in the area of research, and identify a research method suitable for the work. The student will achieve the capability to write a technical paper based on his/her dissertation/ research project.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Explain research ethics, Citation, Impact factor and Plagiarism	Apply
CO2	Formulate a research problem, make a suitable research design, and identify the data collection methods	Apply
CO3	Analyse the collected data	Analyze
CO4	Explain the role of IPR and Patent law in fostering research work, leading to creation of improved products, thus supporting economic growth and social benefits	Apply
CO5	Develop a technical paper for publication	Apply

iii) SYLLABUS

Introduction to Research Methodology- motivation for research, types of research, ethical issues. Identifying a research area and collecting related literature. Research problem- scope objectives, literature review, identifying research gaps, and formulate the research problem. Research design and methods, data collection and analysis . Copy right – royalty - IPR and patent law. Process of patenting and development, Procedure for grant of patents. Copy left- open access, citation, plagiarism, Impact factor. Writing a technical paper.

iv) REFERENCES

1) Stuart Melville and Wayne Goddard, *Research methodology*: *an introduction for science & engineering students.*
2) Ranjit Kumar, 2nd Edition, *Research Methodology: A Step by Step Guide for beginners.*
3) Ramappa T., *Intellectual Property Rights Under WTO*, S. Chand, 2008.
4) Robert P. Merges, Peter S. Menell, Mark A. Lemley, Intellectual Property in New Technological Age, 2016.
5) Mayall, Industrial Design, McGraw Hill, 1992. Niebel, “Product Design”, McGraw Hill, 1974.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Research Methodology: Motivation towards research, Types of research. Professional ethics in research: Ethical issues, ethical committees. Identification of major conferences and important journals in a chosen area of interest. Collection of at least 10 published papers on a research problem in the chosen area.	6
II	Defining and formulating the research problem: Literature Survey, Analysing the collected papers to understand how the authors have identified the research gaps, arrived at their objectives, and formulated their research problem. Understanding how their research work is different from the previous works in the chosen area.	6
III	Research design and methods: Analyzing the collected papers to understand how the authors have formulated the research methods, both analytical methods and experimental methods. Data Collection and analysis: Analyzing the collected papers to understand the methods of data collection, data processing, analysis strategies, and tools used for analyzing the data.	6
IV	Copy right - royalty - Intellectual property rights and patent law – Process of Patenting and Development, Procedure for grant of patents. Reproduction of published material: Copy left- Open access, Citation and acknowledgement. Plagiarism, Impact factor.	6
V	Technical writing - Structure and components of a typical technical paper, abstract and conclusion, illustrations and tables, bibliography, referencing and footnotes. Writing a technical paper – based on the identified research problem, and using the collected papers, Literature survey, Problem formulation, and Research design, and a hypothetical result.	6
	Total hours	**30**

2. SYLLABI FOR VARIOUS COURSES

(e) LABORATORY COURSES

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26CE269A	Pavement Materials and Evaluation Lab	LBC	0	0	3	2	2026

i) COURSE OBJECTIVES

Goal of this course is to impart knowledge for conducting different tests to characterize aggregates and bitumen to assess their suitability for use under different climatic conditions and types of pavement construction. The course also deals with the design of bituminous mixes (hot mix and cold mix) and estimation of their strength. The course includes study on functional and structural evaluation of pavements.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Analyze the suitability of aggregates and bitumen for bituminous construction using relevant standard test procedures.	Analyze
CO2	Characterize bitumen emulsion by conducting tests as per applicable standard specifications.	Apply
CO3	Apply codal provisions to design bituminous mixes in accordance with established mix design methods.	Apply
CO4	Apply standard laboratory test procedures to evaluate the performance characteristics of bituminous mixes.	Apply
CO5	Apply appropriate testing methods to assess the functional and structural adequacy of pavement layers.	Apply

iii) SYLLABUS

Tests on aggregates, bitumen and emulsion.

Tests on bituminous mixes.

Extraction of binder from bituminous mixes.

Structural and functional evaluation of pavements.

iv) REFERENCES

1) Relevant IS/ASTM/AASHTO standards for the conduct of material characterization experiments of aggregates, bitumen and emulsion.

2) Relevant IS/ASTM/AASHTO standard specifications for material characterization and design of bituminous mixes.

3) Relevant IS standards for the functional and structural evaluation of pavement structures.

v) COURSE PLAN

Experiment Cycle	Contents	No. of hours
I	**Test on aggregates** Sieve Analysis Aggregate impact test Los Angeles abrasion test Shape test Stripping value test	9
II	**Test on bitumen for Viscosity grading and performance grading** Viscosity test using Rotational viscometer and Vacuum capillary viscometer Softening point test Ductility test Penetration test Tests for performance grading using Dynamic Shear Rheometer (Study/ demonstration) Tests on bitumen emulsion	14
III	**Test on bituminous Mixes** Marshall Mix design Indirect tensile strength test Rut wheel test Preparation and test on cold mixes Bitumen extraction	12
IV	**Pavement evaluation** Roughness measurement using MERLIN Benkelman beam deflection study and analysis Falling weight deflectometer study (demonstration)	10
	Total hours	45

Course Code	Course Name	Category Code	L	T	P	Credit	Year of Introduction
26CE269B	Transportation Planning and Traffic Lab	LBC	0	0	3	2	2026

i) COURSE OBJECTIVES

The goal of this course to provide a thorough understanding of the various procedures involved in collecting and analyzing traffic inventory. The course also discusses the methods of data collection for estimating the traffic stream parameters, traffic noise and vehicular emission. An introduction to different software for traffic simulation and transportation planning is also included in the course.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Make use of relevant procedures to identify, classify and record the various traffic control devices, pedestrian facilities and parking features in a traffic corridor.	Apply
CO2	Apply standard techniques to collect data and estimate the various micro and macroscopic characteristics of a traffic stream and their inter-dependencies.	Apply
CO3	Examine the extend of noise pollution and vehicular emission in a traffic corridor.	Apply
CO4	Ultilize relevant software applications for traffic simulation and transportation planning	Apply

iii) SYLLABUS

Road inventory survey.

Study on traffic stream characteristics

Study on traffic noise and vehicular emissions.

Traffic simulation and transportation planning using relevant software.

iv) REFERENCES

1) Pignataro L. J., *Traffic Engineering -Theory and Practice*, New Jersey: Prentice Hall, 1973 (Digitized in 2011).
2) Kadiyali. L R. '*Traffic Engineering and Transport Planning*', Khanna Publishers, 9th edition, 2025.
3) Matson, Theodore, M., Smith, W. S., and Hurd, F. W., 'Traffic Engineering', McGraw Hill Book Co., 1955.
4) Wells, G. R., 'Traffic Engineering-An Introduction',Griffin & Co. Ltd, London, England, 1970.
5) Relevant IRC publications.
6) The Noise Pollution (Regulation & Control) Rules, 2000., S.O 123 (E), (Amendment 2010), Ministry of Environment and Forests, Government of India.

7) Bharat Stage Emission Standards.

v) COURSE PLAN

Experiment Cycle	Contents	No. of hours
I	Inventory on: a. Traffic control devices b. Pedestrian facilities c. Parking facilities Study on traffic stream characteristics: d. Travel time and delay e. Spot speed f. Turning movement and peak hour factor g. Sight distance and Gap at intersections h. Saturation flow rate i. Headway j. Level of service k. Parking Study on: l. Traffic noise m. Vehicle emission	**30**
II	Software applications in Traffic Engineering and Transportation Planning a. VISSIM and VISUM b. Introduction to Trans CAD	**15**
	Total hours	**45**

Assessment Pattern

a) Program Core Course/ Program Core Course with practical component

A PCC/ PCCP is evaluated out of 100 marks; 50 marks for Continuous internal assessment (CIA) and 50 marks for End semester evaluation (ESE).

Evaluation shall include application, analysis, and design based questions for both CIA and ESE.

Continuous Internal Assessment (CIA): 50 marks

Micro project/Laboratory/ Course based project: 30 marks

Course based task/ Seminar/Quiz: 10 marks

Continuous Assessment Test (CAT), 1 No: 10 marks
(CAT shall include minimum 60% of the syllabus)

Micro project/ Course based project shall be done individually. Group projects are not permitted.

End Semester Examination (ESE): 50 marks

ESE will be conducted by the Controller of Examinations (CoE). Duration of the examination shall be 180 minutes.

The question paper will contain 7 questions with minimum one question from each module, having 10 marks for each question. A question can have sub parts. Students shall answer any five questions.

The questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, overall achievement and maturity of the students in a course, through questions relating to theoretical/ practical knowledge, derivations, problem solving and quantitative evaluation.

b) Program Elective Course/ Program Elective Course with practical component

A Program Elective Course conducted as a theory course along with its related laboratory experiments comes under the course type PECP. A PEC/ PECP is evaluated out of 100 marks; 50 marks for CIA and 50 marks for ESE.

Evaluation shall include application, analysis, and design based questions for both CIA and ESE.

Continuous Internal Assessment: 50 marks

Preparing a review article based on peer reviewed original publications
(Minimum 10 publications shall be referred)/ Micro project/Laboratory : 30 marks

Course based task/ Seminar/ Data collection and interpretation: 10 marks

Continuous Assessment Test (CAT), 1 No: 10 marks
(CAT shall include minimum 60% of the syllabus)

End Semester Examination: 50 marks

The ESE will be conducted by the CoE. Duration of the examination shall be 180 minutes.

The question paper will contain 7 questions with minimum one question from each module, having 10 marks for each question. A question can have two or more sub parts. Students shall answer any five questions.

The questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, testing of overall achievement and maturity of the students in a course, through questions relating to theoretical/ practical knowledge, derivations, problem solving and quantitative evaluation.

c) Audit Course (Research Methodology and IPR)

An audit course is evaluated out of 100 marks; 50 marks for CIA and 50 marks for ESE.

Continuous Internal Evaluation: 50 marks

Course based task: 20 marks

Seminar/Quiz: 20 marks

Continuous assessment Test (CAT), 1 No: 10 marks
(CAT shall include minimum 60% of the syllabus)

End Semester Examination: 50 marks

The ESE will be conducted by the CoE. Duration of the examination shall be 180 minutes.

The question paper will contain 7 questions with minimum one question from each module, having 10 marks for each question. Students shall answer any five questions.

d) Internship

Internships are educational and career development opportunities, providing practical experience in a field or discipline. They are structured, short-term, supervised placements often focused around particular tasks or projects with defined timescales. A student has the opportunity to do internship for one semester either in M3 or in M4. Such students will carry out a Project work in the other semester.

A student shall carry out the Internship at an Industry/ Research Organization or at another institute of higher learning and repute (Academia). The students must select the organization for doing Internship on their own, with prior approval from the respective PG Programme coordinator. Every student shall be assigned a Faculty supervisor at the beginning of his/her Internship. The training shall be related to their specialization. The internship must be carried out for duration of four to five months, during the third semester or fourth semester. On completion of the Internship course, the student is expected to be able to develop skills in facing and solving the problems experienced in the related field.

Types of Internships

- Industry Internship with/ without Stipend
- Government / PSU Internship (BARC/ Railway/ ISRO etc.)

- Internship with prominent education/ Research Institutes
- Internship with Incubation centers/ Start-ups

Guidelines

- The duration of internship must be for a minimum of four months and a maximum of five months.
- Students can take mini projects, assignments, case studies by discussing it with concerned authority from industry and can work on it during internship.
- All students should compulsorily follow the rules and regulations of the industry.
- Every student should take prior permissions from concerned industrial authority if they want to use any drawings, photographs or any other document from industry.
- Student should follow all ethical practices and Standard Operating Procedure (SOP) of the industry.
- Students must take necessary health and safety precautions as laid by the industry.
- Student should contact his /her Guide/Supervisor from the College on a weekly basis to communicate the progress.
- Each student has to maintain a diary/log book
- After completion of internship, students are required to submit
  - ✓ Report of work done
  - ✓ Copy of Internship certificate
  - ✓ Feedback from internship mentor in the place of internship
  - ✓ Proof of stipend (in case of paid internship).

Evaluation of Internship

Internship will be evaluated out of 100 marks for CIA.

Student's diary/ Daily Log:	25 Marks
Evaluation done by the Industry:	25 Marks
Internship Report:	25 Marks
Comprehensive Viva Voce:	25 Marks

Student's Diary/ Daily Log:

The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily training diary the day to day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches and drawings related to the observations made by the students. Student's diary must be signed each day by the supervisor/ in charge of the section where the student has been working.

Format of Student's Diary

Name of the Organization/Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From ..... To .....

Brief description about the nature of internship:

Day	Brief write up about the Activities carried out: Such as design, sketches, result observed, issues identified, data recorded, etc.
1	
2	
3	

Signature of Industry supervisor Signature of Head/ HR Manager

Office Seal

Format of Attendance Sheet

Name of the Organization/ Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From ..... To .....

Month & Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	…
Month & Year																			
Month & Year																			

Signature of Industry supervisor Signature of Head/ HR Manager

Office Seal

Note:

- Student's Diary shall be submitted by the students along with attendance record and an evaluation sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training.
- Attendance Sheet should remain affixed in daily training diary. Do not remove or tear it off.
- Student shall sign in the attendance column. Do not mark 'P'.
- Holidays should be marked in red ink in the attendance column. An absence should be marked as 'A' in red ink.

Student's diary will be evaluated on the basis of the following criteria:

- Regularity in maintenance of the diary
- Adequacy and quality of information recorded
- Drawings, design, sketches and data recorded
- Thought process and recording techniques used
- Organization of the information.

Format for Evaluation of Intern by industry

Student Name : Date:

Supervisor Name : Designation:

Company/ Organization :

Internship Address:

Dates of Internship: From_____ To_____

Please evaluate intern by indicating the frequency with which you observed the following parameters:

Parameters/ Marks	Needs improvement (0 – 0.25 marks)	Satisfactory (0.25 – 0.5 marks)	Good (0.75 marks)	Excellent (1 mark)
Behavior				
Performs in a dependable manner				
Cooperates with coworkers and supervisor				
Shows interest in work				
Learns quickly				
Shows initiative				
Produces high quality work				
Accepts responsibility				
Accepts criticism				

Demonstrates organizational skills				
Uses technical knowledge and expertise				
Shows good judgment				
Demonstrates creativity/ originality				
Analyzes problems effectively				
Is self reliant				
Communicates well				
Writes effectively				
Has a professional attitude				
Gives professional appearance				
Is punctual				
Uses time effectively				

Overall performance of student Intern (Please Tick one):

Needs improvement (0.50 marks)
Satisfactory (1.0 mark)
Good (1.5 marks)
Excellent (2.0 marks)

Additional comments, if any (2 marks):

Signature of Industry Supervisor *Signature of Section Head/HR Manager*

Office Seal

Internship Report:

After completion of the internship, the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period and should be submitted to the faculty Supervisor. The student should prepare the final report on the assigned topics. Diary/ daily log will also help to a great extent in writing the report since much of the information has already been incorporated by the student into the diary. The training report should be signed by the Internship supervisor, PG Programme Coordinator and Faculty mentor.

The Internship report will be evaluated on the basis of following criteria:

- Originality
- Adequacy and purposeful write-up
- Organization, format, drawings, sketches, style, language etc.
- Variety and relevance of learning experience
- Practical applications, relationships with basic theory and concepts taught in the course

Comprehensive Viva Voce:

Viva Voce will be done by a committee comprising Faculty Supervisor, PG Programme Coordinator, and one faculty member from a sister department. This committee shall evaluate the internship report also.

e) Laboratory Courses

Laboratory courses will have only continuous internal assessment and carries 100 marks. Final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

Continuous internal assessment: 100 marks

Performance in regular laboratory experiments:	70 marks
Final assessment/ laboratory test:	30 marks

f) Industry Elective Course

Engineering students frequently aspire to work in areas and domains that are key topics in the industry. There are concerns by recruiters that skill sets of engineering students do not match with the Industry requirements, especially in the field of latest topics.

Industry knowledge aids in the bridge building process between academic institutions and industry. It also aids students in expanding their knowledge and innovating by allowing them to create something new. Core engineering courses provide students with a strong foundation. Evolving technology necessitates new methods and approaches to progress, prosperity, and the inculcation of problem-solving techniques. Industry knowledge will enable the students to deal with any scenario more effectively, thus fulfilling the current industry demands.

Rapid technological advancements have resulted in a massive revival in the way engineering works in the industry. Projects necessitate the integration of knowledge and abilities from a diverse variety of engineering specialties, with the barriers between them becoming increasingly blurred.

Students can choose courses offered by Industries that cover a wide range of highly relevant topics such as artificial intelligence, internet of things, big data, automation, and other relatable courses.

IEC will be evaluated out of 100 marks; 50 marks for CIA and 50 marks for ESE.

Continuous internal assessment: 50 marks

The continuous internal evaluation will be done by the expert in the Industry handling the course, and the coordinator from the college.

Micro project/ Course based project:	30 marks
Course based task/Seminar/Quiz:	10 marks
Continuous assessment Test (CAT), 1 No:	10 marks

(CAT shall include minimum 60% of the syllabus)

End Semester Examination: 50 marks

ESE will be conducted by the CoE using the question paper provided by the industry. Duration of the examination shall be 180 minutes.

The question paper will contain 7 questions with minimum one question from each module, having 10 marks for each question. Students shall answer any five questions. Evaluation of the answer scripts will be done by the expert in the Industry handling the course or the coordinator from the college under the expert's guidance.

g) Skill/ Ability Enhancement Course

SAEC are online MOOC of 12 weeks duration and shall be considered only if it is conducted by the agencies namely AICTE/ NPTEL/ SWAYAM/ NITTTR. The course should have a proctored/ offline end semester examination. Students can do the SAEC credited in M2 according to their convenience from their first semester, but shall complete it by their second semester. Students can do the SAEC credited in M3 according to their convenience from their first semester, but shall complete it by their third semester. The list of MOOC must be those approved by the concerned Board of studies, from which the students can choose their courses. A course may be approved only if at least 70% of the course content matches with the area/ stream of study. The course shall not be considered if its content has more than 50% of overlap with a core/ elective course in the concerned discipline or with an open elective.

A credit of 3 and a grade point of 10 will be awarded to all students whoever successfully completes the SAEC credited in M3. Marks/ GPA awarded to the other SAEC shall be used for SGPA/CGPA computation.

h) Mini Project

Mini project helps to strengthen the understanding of the fundamentals through application of theoretical concepts, and to boost their skills and widen the horizon of thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects enhances problem solving skills. The Mini project ensures preparedness of students to undertake their project work in M3 and M4. Students should identify a topic of interest in consultation with his/her PG Programme Coordinator. They should demonstrate the novelty of the project through the results and outputs. This mini project work is assessed in three evaluations, two interim evaluations and a final evaluation. The evaluations will be done by a committee comprising of Project Coordinator, Two senior faculty members in the department, and the student's Project Supervisor

Final evaluation will be conducted only if the Interim project report approved by the student's supervisor is submitted. The Plagiarism level in the report should be ≤ 25%, assessed based on the overall similarity index given by Turnitin licensed to the College.

Mini Project will be evaluated out of 100 marks under CIA, and has no ESE.

a) First evaluation:

Evaluation committee: 20 marks

Literature Survey: 7 marks

Objectives and Methodology: 7 marks

Clarity of presentation: 6 marks

b) Second evaluation:

Evaluation committee: 20 marks

Design: 7 marks

Implementation plan: 5 marks

Expected results: 8 marks

c) Final evaluation: 60 marks

a) Supervisor/ Guide: 10 marks

Log book and Regularity: 5 marks

Overall evaluation of the project work: 5 marks

b) Evaluation committee: 50 marks

Demonstration of functionality/ specifications: 20 marks

Level of completion: 5 marks

Clarity of presentation: 5 marks

Knowledge on the project work: 5 marks

Interim project report:

Technical content: 5 marks

Adequacy of references: 5 marks

Templates followed: 5 marks

i) Project

The students must carry out the project work either in the college or in any CSIR/ industrial R&D organization/ any other reputed Institute which have facilities to carry out project work in the proposed area.

Project work outside the College:

For doing project work outside the college, the following conditions are to be met:

- They have successfully completed the course work prescribed in the approved curriculum up to the second semester.
- The student has to get prior approval from the DLAC.
- Students availing this facility should continue as regular students of the College.
- Facilities required for doing the project work shall be available in the Organization/ Industry. A certificate stating the time period for which the facilities shall be made available to the student, issued by a competent authority from the Organization/ Industry shall be submitted by the student along with the application.

- The student should have an external as well as an internal supervisor. The internal supervisor should belong to the college and the external supervisor shall be a Scientist or Engineer from the Institution/ Industry/ R&D organization with which the student proposes to do his project work. The external supervisor shall be with a minimum Post graduate degree in the related area.
- The MOOC must be completed as per the curriculum requirements:
- The student has to furnish his/her monthly progress as well as attendance report signed by the external supervisor and submit the same to the concerned internal supervisor.
- The external supervisor is to be preferably present during all the stages of evaluation of the project.

Internship leading to Project:

Students who complete their internship in M3 at some reputed organization are allowed to continue their work as project in their fourth semester, after getting approval from the DLAC. Such students shall make a brief presentation regarding the work they propose to carry out before the DLAC for a detailed scrutiny and to resolve its suitability for accepting it as an M.Tech project. Once accepted, they will be permitted to complete their project in that organization (where they have successfully completed their internship) during their fourth semester.

Project as part of Employment:

Students may be permitted to discontinue the programme and take up a job, provided they have completed all the courses till the second semester (FE status students are not permitted) prescribed in the approved curriculum. The project work can be done during a later period either in the organization where they work if it has R & D facility, or in the College. Such students shall submit an application with details (copy of employment offer, and the plan of completion of their project) to the Dean (PGSR) through the HoD. When the student plans to do the project work in the organization with R & D facility where they are employed, they shall submit a separate application with the following details:

- Name of R & D Organization/Industry
- Name and designation of an external supervisor from the proposed organization/ industry (a scientist or engineer with a minimum post graduate degree in the related area), along with his profile, and consent letter.
- Name and designation of a faculty member of the College as internal supervisor, and his/her consent letter.
- Letter from the competent authority from the Organization/ Industry granting permission to do the project work.
- Details of the proposed project work along with the work plan for completion of the project.

DLAC will scrutinize the proposal and forward to CLAC for approval.

When a student does his project work along with the job in the organization (with R & D facility) where they are employed, the project work shall be completed in four semesters (two semesters of dissertation work along with the job may be considered as equivalent to one semester of dissertation work at the college). He should complete the M. Tech programme within four years

from the date of admission as per the regulation. Extensions may be granted based on requests from the student and recommendation of the supervisors. Method of assessment of the project will be the same as in the case of regular students.

Evaluation of Project (Phase I) in M3

Project (Phase I) will be evaluated out of 100 marks under CIA, and has no ESE. There will be two evaluations (first evaluation and final evaluation). The assessment shall be done by the student's Project Supervisor, and a committee comprising of Project Coordinator, two senior faculty members in the department, and the student's Project Supervisor. Project Coordinator shall enter the marks in the CoE portal.

Final evaluation will be conducted only if the student has submitted the Interim project report approved by the Supervisor, and Plagiarism level in the Interim project report is ≤25%.

1) **First evaluation: 30 marks**

Project Supervisor: 10 marks

i. Progress of work: 5 marks
(Literature Survey, Objectives, Methodology)

ii. Log book and Regularity: 5 marks

Evaluation committee: 20 marks

i. Topic, Objectives: 5 marks

ii. Methodology and Implementation plan for the work in M3: 10 marks

iii. Clarity in presentation: 5 marks

2) **Final evaluation: 70 marks**

Project Supervisor: 25 marks

i. Progress of work: 15 marks

ii. Log book and Regularity: 5 marks

iii. Interim project report: 5 marks

Evaluation committee: 45 marks

i. Demonstration of work completed: 15 marks

ii. Presentation and Viva voce: 10 marks

iii. Implementation plan of work in M4: 5 marks

iv. Interim project report: 15 marks
Technical content: 10 marks
Adequacy of references and Templates followed: 5 marks

Evaluation of Project (Phase II) in M4/ Project in M3 or M4

The evaluation of Project (Phase II) has CIA for 100 marks, and ESE for 100 marks. The continuous internal assessment is done under two evaluations (first evaluation and final evaluation), by the student's Project Supervisor, and a committee comprising of Project Coordinator, two senior faculty members in the department, and the student's Project Supervisor. Project Coordinator shall enter the marks in the CoE portal.

Final evaluation will be conducted only if the student has submitted the project report approved by the Supervisor, and Plagiarism level in the project report is ≤25%.

Continuous internal assessment: 100 marks

1) **First evaluation: 40 marks**

Project Supervisor: 15 marks

i. Progress of work: 10 marks
(Experimentation and results)

ii. Log book and Regularity: 5 marks

Evaluation committee: 25 marks

i. Demonstration of work completed: 15 marks

ii. Presentation and Viva: 10 marks

2) **Final evaluation: 60 marks**

Project Supervisor: 15 marks

i. Progress of work: 10 marks
(Quality and quantum of work)

ii. Project report: 5 marks

Evaluation committee: 45 marks

i. Demonstration of work completed: 10 marks

ii. Presentation and viva: 10 marks

iii. Project report: 10 marks
Technical content: 5 marks
Adequacy of references: 5 marks

iv. Paper publication: 15 marks
(Published/accepted for publication in a journal/conference)

End semester examination (Viva-voce examination): 100 marks

The ESE will be done by a committee that comprises of the Project Coordinator, an external expert (from industry or research/academic institute), and the student's Project Supervisor

Each department must submit a panel of external experts to Dean (PGSR), as per the academic calendar. The minimum qualification requirement for an external examiner is M.Tech. The number of experts to be submitted is one more than number of students divided by 6 (rounded to the next integer). Honorarium for the external expert will be as fixed by the College.

The Project coordinator will enter the ESE marks in the CoE portal.

Marks Distribution for Viva-voce examination

i. Innovation & originality: 15 marks
(Introduction, Recent and related literature, Scope of the work, Objectives)

ii. Implementation and execution: 20 marks
(Methodology and work plan, Results and discussions, Quality of work done)

iii. Project Documentation: 20 marks
(Introduction, Problem Statement , Literature review, Methodology, Results and discussions, Conclusions, Future work, References)

iv. Presentation and Defense: 40 marks
(Clarity and effectiveness of presentation, Ability to explain the project objectives, Methodology and Findings, Handling questions and providing satisfactory answers)

v. Publication: 5 marks
(Published/accepted for publication in a journal/conference)