R18

M.Tech. (HIGHWAY ENGINEERING)

M.Tech. R18 CBCS Curriculum

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

An Autonomous, ISO 9001:2015 & QS I-Gauge Diamond Rated Institute, Accredited by NAAC with 'A++' Grade
NBA Accreditation for B.Tech. CE, EEE, ME, ECE, CSE, EIE, IT Programmes
Approved by AICTE, New Delhi, Affiliated to JNTUH, NIRF 127 Rank in Engineering Category
Recognized as "College with Potential for Excellence" by UGC
Vignana Jyothi Nagar, Pragathi Nagar, Nizampet (S.O), Hyderabad – 500 090, TS, India.
Telephone No: 040-2304 2758/59/60, Fax: 040-23042761
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VISION OF THE INSTITUTE

To be a World Class University providing value-based education, conducting interdisciplinary research in cutting edge technologies leading to sustainable development of the nation

MISSION OF THE INSTITUTE

- To produce technically competent and socially responsible engineers, managers and entrepreneurs, who will be future ready.
- To involve students and faculty in innovative research projects linked with industry, academic and research institutions in India and abroad.
- To use modern pedagogy for improving the teaching-learning process.

DEPARTMENT OF

CIVIL ENGINEERING

VISION OF THE DEPARTMENT

To develop Civil Engineering Department as a Centre of excellence for imparting value based education to the students at undergraduate and post-graduate level to meet industry needs and to develop as a major research center meeting national and international standards.

MISSION OF THE DEPARTMENT

- To impart in-depth and up-to-date knowledge of Civil Engineering concepts with focus on character enhancement, leadership qualities, effective communication, social responsibility and pursuit of lifelong learning and professional development.

- To provide a platform to the students to engage in original innovative research.

M.TECH.
(HIGHWAY ENGINEERING)

M.TECH. (HWE)

PROGRAM EDUCATIONAL OBJECTIVES

PEO-I: To provide the student with a solid foundation in Planning, Design, Construction, Operation and Maintenance of highway projects in the context of environmental, economic and social requirements.

PEO-II: To equip students with modern concepts and tools which would enable them to become globally competent professionals and fitting into a broad range of career opportunities in highway research and industry.

PEO-III: To prepare the students in lifelong learning for professional advancement, that would help them to execute complex transportation projects with professional ethics and social responsibilities.

M.TECH. (HWE)

PROGRAM OUTCOMES

PO-1: The student is capable of applying the principles of basic science, engineering and optimization techniques to solve highway engineering problems.

PO-2: The graduates will possess critical thinking skills, problem solving abilities, and familiarity with the computational procedures essential to the field.

PO-3: The student is able to plan, analyze, design, synthesize and execute complex highway infrastructure projects considering societal and environmental considerations.

PO-4: The student will use research based knowledge and methods to design, conduct experiments and to analyze and interpret experimental data to provide sustainable engineering solutions for highway related societal problems in local and global context.

PO-5: The student will get hands on training in various Modern Highway Engineering software's and modern equipment.

PO-6: The Students will apply reasoning informed by the appropriate knowledge to assess societal, health, safety, legal and cultural issues

PO-7: As the students possess substantial knowledge in multi-disciplinary subjects, they will be able to plan various projects keeping in view its environmental effects on other related fields.

PO-8: The student will practice and apply professional skills with social responsibility

PO-9: The Graduate can function effectively in multi-disciplinary projects and demonstrate leadership qualities.

PO-10: The Student will excel in expressing ideas, writing technical reports with good communication and managerial skills.

PO-11: The Graduates will demonstrate knowledge and understanding of the critical issues for professional practices such as the procurement of works, interaction with contractors during the construction phase of a project, the finance management and managerial capabilities.

PO-12: The student engages in lifelong learning for professional advancement.

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY, HYDERABAD
M.TECH. I YEAR COURSE STRUCTURE AND SYLLABUS

(HIGHWAY ENGINEERING)

I SEMESTER **R18**

Course Type	Course Code	Name of the Course	L	T	P	Credits
Professional Core-I	18PC1HW01	Pavement Material Characterization	3	0	0	3
Professional Core-II	18PC1HW02	Traffic Engineering	3	0	0	3
Professional Core-III	18PC1HW03	Highway Geometric Design	3	0	0	3
Professional Elective-I	18PE1HW01	Urban Transportation Planning	3	0	0	3
	18PE1ST13	Principles of Bridge Engineering				
	18PE1HW02	Intelligent Transportation Systems				
Professional Elective-II	18PE1HW03	Remote Sensing and GIS Applications in Highways	3	0	0	3
	18PE1HW04	Road Safety and Traffic Management				
	18PE1HW05	Environmental Impact Assessment for Highway Projects				
Professional Core Lab-I	18PC2HW01	Pavement Engineering Laboratory	0	0	3	1.5
Professional Core Lab-II	18PC2HW02	Traffic Engineering Field Laboratory	0	0	3	1.5
Project	18PW4HW01	Technical Seminar	0	0	4	2
Audit	18AU5CS01	Research Methodology and IPR	2	0	0	0
Total			**17**	**0**	**10**	**20**

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY, HYDERABAD
M.TECH. I YEAR COURSE STRUCTURE AND SYLLABUS

(HIGHWAY ENGINEERING)

II SEMESTER **R18**

Course Type	Course Code	Name of the Course	L	T	P	Credits
Professional Core-IV	18PC1HW04	Pavement Analysis and Design	3	0	0	3
Professional Core-V	18PC1HW05	Highway Project Formulation and Economics	3	0	0	3
Professional Core-VI	18PC1HW06	Advanced Traffic Analysis	3	0	0	3
Professional Elective-III	18PE1HW06	Numerical Methods and Applied Statistics	3	0	0	3
	18PE1HW07	Computational Techniques in Highway Engineering				
	18PE1HW08	Highway Network Analysis and Optimization Techniques				
Professional Elective-IV	18PE1GT01	Soil Structure Interaction	3	0	0	3
	18PE1HW09	Pavement Management Systems				
	18PE1HW10	Mass Transportation System and Planning				
Professional Core Lab-III	18PC2HW03	Highway Material Characterization and Traffic Simulation Laboratory	0	0	3	1.5
Professional Core Lab-IV	18PC2HW04	Highway Numerical Analysis Laboratory	0	0	3	1.5
Project	18PW4HW02	Mini-Project	0	0	4	2
Audit	18AU5EN01	English for Academic and Research Writing	2	0	0	0
Total			**17**	**0**	**10**	**20**

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY, HYDERABAD
M.TECH. II YEAR COURSE STRUCTURE AND SYLLABUS

(HIGHWAY ENGINEERING)

III SEMESTER **R18**

Course Type	Course Code	Name of the Course	L	T	P	Credits
Professional Elective-V	18PE1HW11	Highway Construction and Quality Control	3	0	0	3
	18PE1HW12	Evaluation and Strengthening of Pavements				
	18PE1HW13	Advanced Highway Materials				
Open Elective	18OE1CN01	Business Analytics	3	0	0	3
	18OE1AM01	Industrial Safety				
	18OE1AM02	Operations Research				
	18OE1AM03	Composite Materials				
	18OE1PS01	Waste to Energy				
Project	18PW4HW03	Project Part - I	0	0	16	8
Total			**6**	**0**	**16**	**14**

IV SEMESTER **R18**

Course Type	Course Code	Name of the Course	L	T	P	Credits
Project	18PW4HW04	Project Part - II	0	0	28	14
Total			**0**	**0**	**28**	**14**

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

M.Tech. I Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18PC1HW01) PAVEMENT MATERIAL CHARACTERIZATION

COURSE OBJECTIVES:

- To understand properties and tests performed on sub grade soil, aggregates
- To learn different soil stabilization techniques
- To appreciate different tests performed on bitumen and techniques to improve its properties
- To gain knowledge on quality of cements its IRC methods for concrete mix design and role of Admixtures

COURSE OUTCOMES: After completion of the course, students should be able to

CO-1: Explain properties and tests performed on sub grade soil, aggregate, bitumen and cement

CO-2: Understand soil stabilization and how it is done

CO-3: Comprehend how to improve bitumen properties by modification techniques

CO-4: Aware of advanced concrete used in road construction, role of admixtures and design of concrete mixes

UNIT-I:

Sub-grade Soil Characterization: Soil Classification; Index and other basic properties of soil; Types of soils used for construction of different layers of pavement, embankments and their suitability-requirements, Mechanical response of soil- different laboratory and in-situ procedures for evaluating the mechanical properties of soils viz. SPT, DCPT, CBR, Plate Load test & resilient modulus test.

UNIT-II:

Introduction to Soil Stabilization: Physical and Chemical modification - Stabilization with admixtures- cement, lime, calcium chloride, Fly ash and bitumen. Grouting; Categories of grouting, Art of grouting, Grout materials, Grouting techniques and control - Geo textiles and synthetics applications in highway constructions.

UNIT-III:

Road Construction Aggregate: Origin, Classification, different sizes of aggregates-suitability of aggregates in pavements layers - different tests on aggregates-limiting values as per MORTH for different layers, Methods of Proportioning and Blending of aggregates, Fuller and Thompson's Equation, 0.45 power maximum density graph; Introduction to Super pave gradation.

UNIT-IV:

Bituminous Road Binders and Mixes: Elastic modulus, Dynamic modulus, visco-elastic and fatigue properties, creep, Long term and short term ageing and its effect on bitumen performance. Desirable properties of bituminous mixes- Marsahll method of mix design.

UNIT-V:

Modified Bituminous Binders and Mix Design: Crumb Rubber modified bitumen, natural rubber modified bitumen; polymer modified bitumen; Introduction to emulsified bitumen; Foamed bitumen; super pave mix design procedure; resilient and complex (dynamic) modulus- nano technology in bituminous concrete mixture.

UNIT-VI:

Cement Concrete Mix Characterization: Introduction to advanced concretes like self compacted concrete; light weight concrete; roller compacted concrete for pavement

application; Role of different admixtures in cement concrete performance; Joint filers for jointed plain cement concrete pavements; Nano technology applications in cement concrete.

TEXT BOOKS:

1. Mix Design Methods – For Asphalt Concrete and Other Hot-Mix Types Manual Series No. 2 (MS-2), Asphalt Institute, Kentucky, USA, 1997
2. Highway Materials, Soils and Concretes, Atkins, N. Harold, Fourth Edition, Prentice-Hall, 1980,
3. Highway Materials, Kerbs Robert D. and Richard D. Walker, McGraw-Hill, 1971

REFERENCES:

1. Ministry of Road Transport and Highways. Specifications for Road and Bridge Works, Fifth Revision, Indian Roads Congress, New Delhi, India
2. The Shell Bitumen Handbook, Read J. and Whiteoak D., Fifth Edition, Shell Bitumen, Thomas, Telford Publishing, London 2003
3. Pavement Engineering – Principles and Practice, Mallick R. B. and T. El-Korchi, CRC Press, Taylor and Francis Group, Florida, USA, 2009

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M.Tech. I Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18PC1HW02) TRAFFIC ENGINEERING

COURSE OBJECTIVES:
- To introduce students on the basic concepts of traffic engineering
- To analyze capacity and level of service of highways
- To identify the importance and types of parking and traffic safety in day-to-day life
- To design signals at the intersection.

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Explain basic characteristics of traffic engineering like speed, flow and density
CO-2: Analyze and calculate the capacity and level of service of any given highway
CO-3: Formulate the parking demand and design a parking facility
CO-4: Design the signals at the intersection

UNIT-I:
Basic Traffic Stream Characteristics: Speed, flow and density, Relationship between Speed, Flow and density; Volume Studies - Objectives, Methods; Speed studies - Objectives: Definition of Spot Speed, time mean speed and space mean speed.

UNIT-II:
Traffic Measurement Procedures: Measurement at a Point (Volume data collection and analysis, PCU, PHF etc), Measurement over a Short Section (Speed data collection and analysis), Measurement along a Length of Road (Density and travel time measurement and analysis), Moving Observer Method, Traffic forecasting and growth studies. Microscopic traffic flow modeling: Car Following Models: Linear models, Car Following Models: Non-linear models, Lane Changing Models, Microscopic Traffic Simulation (Vehicle generation, model frame work, calibration and validations, statistical error analysis, applications).

UNIT-III:
Parking Studies and Analysis: Types of parking facilities - on street parking and off street Parking facilities; Parking studies and analysis. Traffic Safety: Accident studies and analysis; Causes of accidents; Engineering, Enforcement and Education measures for the prevention of accidents, Road safety audit.

UNIT-IV:
Traffic Intersection Control: Principles of Traffic Control and Traffic Signs, Road Markings and Channelization, Uncontrolled Intersection: Gap acceptance and capacity concepts, Uncontrolled Intersection: Capacity and LOS analysis, Traffic Rotaries and Grade Separated Intersection. Highway Capacity and Level of Service: Basic definitions related to capacity; Level of service concept; Factors affecting capacity and level of service; Computation of capacity and level of service for two lane highways Multilane highways and freeways.

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

UNIT-VI:
Traffic and Environment: Detrimental effects of Traffic on Environment; Air pollution; Noise Pollution; Measures to curtail environmental degradation due to traffic.

TEXT BOOKS:

1. Traffic Engineering and Transportation Planning, L. R. Kadiyali, Khanna Publishers, 2011
2. Traffic Engineering, Roger P. Roess, Elena S. Prassas and William R. McShane, Prentice Hall, 4th Edition, 2010
3. Traffic & Highway Engineering, Nicholas J. Garber, Lester A. Hoel, Third Edition, Bill, 2011

REFERENCES:

1. Fundamentals of Transportation Engineering, C. S. Papacostas and P. D. Prevedouros, Prentice-Hall, New Delhi, 2009
2. Introductions to Traffic Engineering: A Manual for Data Collection and Analysis, Thomas R. Currin, Brooks/Cole Thomason Learning, Canada, 2001
3. Design Codes: IRC: SP: 41-1994, IRC SP: 31-1992, IRC 43-1994, Indian Roads Congress, New Delhi., Highway Capacity Manual 2010, Transportation Research Board, Indo-HCM, CSIR-CRRI, 2017, New Delhi

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M.Tech. I Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18PC1HW03) HIGHWAY GEOMETRIC DESIGN

COURSE OBJECTIVES:

- To understand the various factors affecting in pavement design
- To knowledge on design aspects and methods for rural and urban roads
- To introduce students the principal of highway design, road safety and highway construction materials
- To start applying these skills to design roads and select material for road construction

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Apply knowledge in fixation of ideal alignment and design of highway
CO-2: Describe design element: sight distance, horizontal curvature, super elevation, grades, visibility on vertical curves, cross section elements
CO-3: Use fundamental physics and mathematical knowledge in deriving geometric design equations
CO-4: Plan surveys, preparation of survey forms and data collection from field for highway design

UNIT-I:
Highway System: Functional Classification of Highway System, Highway Design Controls: Topography, Driver characteristics, Vehicle Characteristics, Traffic, Capacity and Level of Service, Design Speed - Objectives of Geometric Design - Cross Section Elements: IRC Design specifications, Pavement Surface characteristics: Skid Resistance, Road Roughness; Camber.

UNIT-II:
Geometric Design of Highway Element: Sight distances: Objectives, Types, factors affecting, Problems on Sight distance, Alignment: Types, Objective and Factors affecting alignment, Horizontal alignment: Objectives, design Criteria, super-elevation, extra widening and Design of transition curves. Vertical alignment: Objectives, design Criteria, Types of gradient, Grade Compensation, design of summit and valley curves, combination of vertical and horizontal Alignment.

UNIT-III:
Intersection Design: Introduction of Intersection Design: Objectives, Types of Intersections, Design Principles for Intersections. Design of At-grade Intersections: Objectives, Channelization, Traffic Islands and Design standards for intersection. Design of Rotary Intersection: Objectives, Advantages and Disadvantages and determining the capacity. Grade separated Interchanges: Objectives, Types, warrants and Design standards.

UNIT-IV:
Highway Design and Specifications: Design Considerations: Design considerations for rural, urban arterials, expressways, and other rural Roads. Urban roads -design speeds, volumes, level of service - IRC Specification for Expressway and Rural Roads. Design of expressways, IRC standards and guidelines for design - Specifications for hill roads.

UNIT-V:
Active Transportation Facilities: Pedestrian facilities: Objectives of Pedestrian facilities, Types of Pedestrian facilities on Urban Roads and IRC Specification - Cycle Tracks: Objectives, Types of cycle track.

UNIT-VI:

Miscellaneous Facilities on Highway: Bus bays: Objectives, types, guidelines and IRC Design standards - Parking facilities: Objectives, Types, Guidelines and IRC Design standards.

TEXT BOOKS:

1. Principles and Practice of Highway Engineering, L. R. Kadiyali and N. B. Lal, Khanna, 7th Edition, 2007
2. Traffic Engineering and Transportation Planning, L. R. Kadiyali and N. B. Lal, Khanna Publishers, 2009
3. Highway Engineering, S. K. Khanna, C. E. G. Justo and Veeraraghavan A., 10th Ed., Nem Chand & Bros, 2013

REFERENCES:

1. Transportation Engineering-An Introduction, C. Jotin Khisty and B. Kent Lall, Prentice-Hall, India, 2008
2. IRC Codes for Signs, Markings and Mixed Traffic Control in Urban Areas
3. Design Codes IRC: SP: 41-1994, IRC SP: 31-1992, IRC 43-1994, Indian Roads Congress, New Delhi. Highway Capacity Manual 2010, Transportation Research Board, Indo HCM, 2017, CSIR CRRI, New Delhi

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M.Tech. I Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18PE1HW01) URBAN TRANSPORTATION PLANNING

COURSE OBJECTIVES:

- To introduce students on basic concepts and methods of urban transportation planning in the India
- To design, conduct and administer surveys to provide the data required for transportation planning
- To understand and apply travel demand modeling, mode choice modeling and traffic Assignment Modeling
- To identify importance of transportation planning in cities

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Plan and conduct surveys to provide the data required for transportation planning
CO-2: Recognize zonal demand generation and attraction regression models
CO-3: Develop and calibrate trip generation rates for specific types of land use developments
CO-4: Predict the final decisions among planning alternatives that best integrate multiple objectives such as technical feasibility and cost minimization

UNIT-I:
Urban Transportation Planning: Goals and objectives - Hierarchical levels of Transportation planning - Forecast - Implementation - Constraints. UTP survey – Inventory of land use- Introduction of classical four stage modeling. Zonal Classifications.

UNIT-II:
Trip Generation and Trip Distribution: Trip classification - productions and attractions - Multiple regression models - Category analysis - Trip production models - Trip distribution models – Linear programming approach.

UNIT-III:
Mode Split: Behavioral models - Probabilistic models – Utility functions – logit models - Two stage model.

UNIT-IV:
Traffic Assignment: - Assignment methods – Route choice behaviour - Network analysis.

UNIT-V:
Land-use and its Interaction: Lowry derivative models - Non- Transport solutions for transport problems. Characteristics of urban structure; Town planning concepts.

UNIT-VI:
Applications of UTP: Preparation of alternative plans - Evaluation techniques – Plan implementation – Monitoring.

TEXT BOOKS:

1. Principles of Urban Transportation System Planning, Hutchinson B. G., McGraw Hill, 1974
2. An Introduction to Transportation Planning (The Living Environment), Bruton M. J., UCL Press, London, UK, 2000
3. Transportation Engineering, C. J. Khisty and B. Kent Lall, Prentice Hall of India Pvt. Ltd., 2002

REFERENCES:

1. Transportation Engineering and Planning, C. S. Papacostas and P. D. Prevedouros, Prentice Hall of India Pvt. Ltd., 2001
2. UTP Lecture Notes, Chari S. R. Regional Engg. College, Warangal 1978
3. Metropolitan Transportation Planning, Dicky J. W., Script Book Co., Washington D. C., 1975
4. Modelling Transport, Ortuzar J. and Willumsen L. G., Wiley, Chinchestor, 1994

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M.Tech. I Semester (HWE)	**L**	**T/P**	**C**
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(18PE1ST13) PRINCIPLES OF BRIDGE ENGINEERING

COURSE OBJECTIVES:
- To understand the bridge hydrology
- To list the components of bridge substructure, superstructure and types of bearings
- To understand the codal provisions for loading and design standards of bridges
- To design RC and PSC bridges

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Determine flood discharge, waterway, economic span
CO-2: Select type of super structure, sub structure and the bearings
CO-3: Calculate the various types of acting on the loads
CO-4: Design the Slab bridges, Girder bridges and Prestressed Concrete bridges

UNIT-I:
Introduction: Components of a bridge, Classification of bridges, Requirements of an ideal bridge, Selection of bridge site, Choice of bridge type, Investigation for bridges.
Bridge Hydrology: Determination of flood discharge, Waterway, Economic span, Scour depth, Depth of foundation, Afflux, Clearance, Freeboard

UNIT-II:
Bridge Substructure and Superstructure: Bridge Piers, Abutments, Wing walls, Approaches, Types of bridge superstructures, Bridge flooring, Choice of superstructure type.

UNIT-III:
Standards of Loadings for Bridge Design: Types of loading for Road bridges – Dead load, Live load, Impact load, Wind loads, Lateral loads, Longitudinal forces, Centrifugal forces, Seismic loads, Forces due to water currents, Earth pressure, Buoyancy, Temperature stresses Deformation stresses, Erection stresses, Requirements of traffic in the design of highway bridges.

UNIT-IV:
Reinforced Concrete Bridges: Design of Slab bridge, Design of Girder bridge, Courbon's theory.

UNIT-V:
Prestressed Concrete Bridges: Types of prestressing – Pre tensioning, Post tensioning, Pretensioned PSC bridges, Post tensioned PSC bridges.

UNIT-VI:
Bridge Bearings and Expansion Joints: Functions, types and selection of bearings - Bearing materials - Design of elastomeric bearings for different conditions - Expansion joints – types of expansion joints.

TEXT BOOKS:
1. Principles and Practice of Bridge Engineering, S. P. Bindra, Dhanpat Rai Publications
2. Design of Concrete Bridges, M. G. Aswani, V. N. Vazirani, M. M. Ratwani, Khanna Publishers
3. Essentials of Bridge Engineering, D. J. Victor, Oxford & IBH Publishing Co.

REFERENCES:
1. Design of Bridge Structures, T. R. Jagdeesh and M. A. Jayaram, PHI

2. Bridge Engineering, Ponnuswamy S., Tata McGraw Hill Publishing Co., New Delhi, 1986
3. Analysis and Design of Substructures, Swami Saran, Oxford & IBH Publishing Co.

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M.Tech. I Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18PE1HW02) INTELLIGENT TRANSPORTATION SYSTEMS

COURSE OBJECTIVES:
- To understand ITS architecture and standards
- To apply appropriate ITS technology depending upon site specific conditions
- To design and implement ITS components
- To understand concept and application of Automated Highway Systems

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Differentiate different ITS user Services
CO-2: Apply ITS for road user safety
CO-3: Interpret importance of AHS in ITS
CO-4: Extend future research and special project

UNIT-I:
Introduction To ITS: System Architecture, Standards, Database – Tracking Database – Commercial Vehicle Operations – Intelligent Vehicle Initiative - Metropolitan ITS – Rural ITS – ITS for Rail network.

UNIT-II:
ITS Travel Management: Autonomous Route Guidance System – Infrastructure based systems – Telecommunications – Vehicle – Road side communication – Vehicle Positioning System – Electronic Toll Collection – Electronic Car Parking

UNIT-III:
ITS Designs: Modeling and Simulation Techniques - Peer – to – Peer Program – ITS for Road Network – System Design – Mobile Navigation Assistant – Traffic Information Center – Public Safety Program.

UNIT-IV:
Automated Highway Systems: Evolution of AHS and Current Vehicle Trends - Vehicles in Platoons – Aerodynamic Benefits - Integration of Automated Highway Systems – System Configurations - Step by Step to an Automated Highway System.

UNIT-V:
Spacing and Capacity for Different AHS Concepts – Communication Technologies for AHS - The Effects of AHS on the Environment – Regional Mobility - Impact Assessment of Highway Automation.

UNIT-VI:
Implementation of ITS: ITS programs globally- overview of ITS in developed countries and developing countries

TEXT BOOKS:
1. ITS Hand Book 2000: Recommendations for World Road Association (PIARC), Kan Paul Chen, John Miles
2. Intelligent Transport Systems – Cases and Policies, Roger R. Stough, Edward Elgar, 2001
3. Intermodal Freight Transport, David Lowe, Elsevier Butterworth-Heinemann Publishers, 2005

REFERENCES:
1. Positioning Systems in Intelligent Transportation Systems, Chris Drane and Chris Rizos, Artech House Publishers, London, 2000

2. Perspectives on Intelligent Transport Systems, Joseph M. Sussman, Springer, 2000
3. Intelligent Transport System, Intelligent Transportation Primer, Washington, US, 2001

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M.Tech. I Semester (HWE)	**L**	**T/P**	**C**
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(18PE1HW03) REMOTE SENSING AND GIS APPLICATIONS IN HIGHWAYS

COURSE OBJECTIVES:
- To describe and define various concepts of Remote Sensing and GIS
- To analyze data using GIS
- To appraise the importance of accuracy in GIS
- To apply GIS knowledge in solving various problems in real world scenario

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Describe different concepts and terms used in GIS
CO-2: Compare and process different data sets
CO-3: Evaluate the accuracy and decide whether a data set can be used or not
CO-4: Demonstrate various applications GIS in highway engineering

UNIT-I:
Remote Sensing: Introduction- Principle of remote sensing, components of remote sensing, Remote sensing platforms, Radiometric quantities, Electromagnetic radiation and its properties, Electromagnetic energy laws, Interaction of EMR with earth features, Interaction of EMR with atmospheric features, atmospheric effects on remote sensing data, spectral reflectance curves, Spectral properties of soil, water, vegetation. Advantages and Disadvantages of Remote Sensing Data

UNIT-II:
Satellites and Sensors: Sensors - Remote sensing sensors types, along track scanners, across track scanners. Sensor Characteristics – Swath, IFOV, Nadir view, Spatial Resolution, Spectral Resolution, Temporal, Resolution, Radiometric resolution, Atmospheric ,Radiometric, Geometric corrections Satellites – Satellite orbits, Geostationary and polar satellites, various satellites and their main applications, IRS satellites.

UNIT-III:
Remote Sensing Data Interpretation, Processing and Enhancement: Elements of visual interpretation, Image enhancement techniques - necessity and importance, contrast enhancement techniques, low pass (smoothing) filters and high pass (sharpening) filters, linear and non-linear filtering techniques, edge detection, supervised classification, unsupervised classification, and Classification accuracy. Introduction to GPS and DGPS.

UNIT-IV:
Geographical Information System: Introduction, Definition and Terminology, Maps and Map Scale, Geo referencing and Projection, Components of GIS, GIS Data Input - Keyboard entry, Manual digitizing, Scanning methods, Errors in digitizing, Data output formatting and output devices,

UNIT-V:
GIS Data Models: Raster, Vector, TIN, Advantages and disadvantages,
Spatial Data Analysis: Vector Operations and Analysis- Single theme and multi themes, Raster data analysis, Interpolation – global and local methods

UNIT-VI:
Applications of GIS in Transportation Engineering: GIS based road network planning, Identification of accident hot spots using GIS, Automatic Navigation system using GPS and GIS, Shortest path applications in GIS, Intelligent transportation systems.

TEXT BOOKS:

1. Remote Sensing and Image Interpretation, Thomas M. Lillesand and Ralph W. Kiefer, Wiley, 2006
2. Introduction to Geographic Information Systems, Kang-tsung Chang, Indian Edition, McGraw-Hill Education, 2008
3. Remote Sensing and GIS, Basudeb Bhatta, Oxford University Press, 2003

REFERENCES:

4. Basics of Remote Sensing and GIS, Dr. S. Kumar, Laxmi Publications, 2002
5. Remote Sensing and Geographical Information systems, M. Anji Reddy, B. S. Publications, 2004
6. Remote Sensing and Geographical Information Systems, Kali Charan Sahu, Atlantic Publishers and Distributors, 2009

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

M.Tech. I Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18PE1HW04) ROAD SAFETY AND TRAFFIC MANAGEMENT

COURSE OBJECTIVES:

- To apply the principles of a systems approach to the analysis of risk factors for road traffic injuries
- To apply methods for reducing traffic impacts on communities such as traffic calming strategies, accident reductions and parking management
- To discuss the key risk factors for road traffic injuries
- To understand the role of ITS in Dynamic Traffic Management

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Explain the factors for road traffic injuries
CO-2: Analyze and provide solutions for traffic calming and parking management
CO-3: Evaluate the risk factors for road traffic injuries
CO-4: Understand the role of ITS in Dynamic Traffic Management

UNIT-I:
Introduction to Crashes: Characteristics of crashes – Human, Vehicle, Road and Environmental factors; Scientific investigations and crash data collection; Crash investigation and analysis – Crash report forms, using and interpreting crash data, condition and collision diagrams; Crash reconstruction – understanding basic physics, calculation of speed for various skid, friction, drag and acceleration scenarios.

UNIT-II:
Statistical Analysis of Crashes: Statistical analysis of crashes, various methodological issues – over/under-dispersion, under reporting, unobserved heterogeneity, endogeneity etc., Safety Performance Functions – models related to crash frequency, crash severity and collision types; Identification of hazardous crash locations. Before and after crash studies – with controlled sites, comparative parallel study and other methods.

UNIT-III:
Road Safety Audits: Procedure, aims and objectives, roles and responsibilities, history of Road Safety Audits (RSA), design standards, tasks, various stages of safety audits, common identifiable problems, identifying common problems, suggesting mitigation measures and structuring of the RSA report.

UNIT-IV:
Traffic Management Techniques: Integrated Safety improvement and Traffic Calming Schemes, speed and load limit, Traffic light, safety cameras, highway patrolling, Test on driver and vehicles, pedestrian safety issues, parking, Parking enforcement and its influences on accidents. Travel demand management;

UNIT-V:
Method of Traffic management measures: Restrictions of Turning movements, One-way streets, Tidal Flow operation methods, Exclusive bus lanes and closing side – streets; latest tools and techniques used for road safety and traffic management. Road safety issues and various measures for road safety; Legislation, Enforcement, Education and Propaganda, Air quality, Noise and Energy Impacts; Cost Road Accidents.

UNIT-VI:
Incident Management: Introduction, characteristics of traffic incidents, types of incidents, Impacts, Incident management process, Incident traffic management; applications of ITS:

Motorist information, Equipment used; Planning effective Incident management program, Best practice in Incident management programs. National importance of survival of Transportation systems during and after disasters especially cyclones, earth quakes, floods etc. and manmade disasters like sabotage, terrorism etc.

TEXT BOOKS:

1. Observational Before-After Studies in Road Safety, Ezra Hauer, Pergamon Press, 1997 (Reprinted 2002)
2. Statistical and Econometric Methods for Transportation Data Analysis, Simon P. Washington, Matthew G. Karlaftis, Fred L. Mannering, 2nd Edition, Chapman and Hall, CRC Press, 2010
3. Traffic Collision Investigation, J. Stannard Baker, North-Western University Centre for Public Safety, 2002

REFERENCES:

1. Traffic Control and Road Accident Prevention, Popkess C. A. Chapman and Hall, 1997
2. The Handbook of Road Safety Measures, Rune Elvik and Truls V., Elsevier, 2004
3. Statistical and Econometric Methods for Transportation Data Analysis, Simon Washington, Matthew K, and Fred Mannering, Chapman & Hall/CRC Press, 2003

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

M.Tech. I Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18PE1HW05) ENVIRONMENTAL IMPACT ASSESSMENT FOR HIGHWAY PROJECTS

COURSE OBJECTIVES:

- To assess environmental impacts of road traffic under various policy options Estimate air pollution concentrations as a function of emission, meteorology, topography and they built environment from road traffic
- To promote the integration of all forms of transport and land use planning, leading to a better, more efficient transport system
- To plan, develop and manage land transport system to support a quality environment while making optimal use of our transport and safeguarding the well-being of the travelling public
- To deliver an effective land transport network that is integrated, efficient, cost-effective and sustainable to meet the nation's needs

COURSE OUTCOMES: After completion of the course, students should be able to

CO-1: Understand national and international contexts on transport and the environment; Basic understanding of the concepts of traffic and environment management for sustainability

CO-2: Knowledge of policies and reports which have a strong bearing on local and global air pollution and sustainability issues

CO-3: Appreciate the multiple complexities of successful planning, data collection and analysis and identification of improvements

CO-4: Realize to current issues relating to traffic flow, road safety and air quality

UNIT-I:

Introduction: Environment and its interaction with human activities – Environmental imbalances. Attributes, Impacts, 'Indicators and Measurements - Concept of Environmental Impact Assessment (EIA); Environmental Impact Statement, Objectives of EIA, Advantages and Limitations of EIA

UNIT-II:

Environmental Indicators: Indicators for climate - Indicators for terrestrial subsystems - Indicators for aquatic subsystems - Selection of indicators - Socio-economic indicators – Basic information - Indicators for economy - Social indicators - Indicators for health and nutrition - Cultural indicators - Selection of indicators.

UNIT-III:

Environmental Issues: Water resource development - Land use - Soil erosion C1nd their short and long term effects - Disturbance and long term impacts - Changes in quantity and quality of flow ¬Sedimentation –

UNIT-IV:

Environmental Assessment: water resource development structures – Case studies, Water Quality Impact Assessment - Attributes, Water Quality Impact Assessment of Water

UNIT-V:

Project Resources: Data Requirements of Water Quality Impact Assessment for Dams, Impacts of Damson Environment, Case Studies. Environmental Issues in Industrial Development: On-site and Off-site impacts during various stages of industrial development, Long term climatic changes, Greenhouse effect, Industrial effluents and their impaction natural cycle, Environmental impact of Highways, Mining and Energy development

UNIT-VI:

Methodologies for Carrying Environmental Impact Assessment: Overview of Methodologies, Ad hoc, Checklist, Matrix, Network, Overlays, Benefit Cost Analysis, Choosing a Methodology, Review Criteria.

TEXT BOOKS:

1. Environmental Impact Assessment, Canter L. W., McGraw Hill Pub. Co., New York, 1997
2. Environmental Analysis of Transportation Systems, Louis Franklin Cohen and Gary Richard Mc Voy, John Wiley & Sons, 1982
3. Environmental Impact Analysis, Jain, R.K., Urban, L.V., Stracy, G.S., an Nostrand Reinhold Co., New York, 1991

REFERENCES:

1. Environmental Fate and Transport Analysis with Compartment Modeling, Keith W. Little, CRC Press, Taylor & Francis Group, 2012
2. NCHRP Report 541, Consideration of Environmental Factors in Transportation Systems Planning, TRB, 2005
3. NCHRP Synthesis 272, Best Management Practices for Environmental Issues Related to Highway and Street Maintenance: A Synthesis of Highway Practice, National Research Council, TRB, 1999

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M.Tech. I Semester (HWE)	**L**	**T/P**	**C**
	0	**3**	**1.5**

(18PC2HW01) PAVEMENT ENGINEERING LABORATORY

COURSE OBJECTIVES:
- To learn the properties of aggregate used in pavement constructions
- To design the base courses of pavement layers
- To understand the grading of bitumen binders
- To gain Knowledge on design of bituminous mix using Marshall Process

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Identify the suitability aggregate used in pavement constructions
CO-2: Evaluate the design process for base course layers
CO-3: Appreciate different tests performed on bitumen grading
CO-4: Comprehend how to perform bituminous mix design

CYCLE I
Tests on Aggregates:
a) Aggregate Impact Test
b) Los Angeles Abrasion Test
c) Crushing strength of Aggregates
d) Specific Gravity and Water Absorption Test
e) Soundness test.

CYCLE II
Mix Design for Base Layers:
a) Wet Mix Macadam – CBR method.

CYCLE III
Bitumen & Bituminous Mixes: Bitumen Grading:
a) Absolute & Kinematic Viscosity
b) Penetration Test
c) Softening point
d) flash & fire point Mix Design
e) Marshall Stability mix design – Analysis
f) Determination Binder content.

TEXT BOOKS:
1. Highway Materials and Pavement Testing, Khanna S. K., Justo C. E. G. and A. Veeraragavan, 5th Edition, Nem Chand and Brothers, Roorkee, India, 2009
2. Pavement Analysis and Design, Huang Y. H., Pearson Prentice Hall, New Jersey, USA, 2004

REFERENCES:
1. Relevant IS, IRC, ASTM Codes

Note: All tests are performed as **per IS, ASTM, AASHTO, TRL, IRC, BS** procedures / specifications and guidelines

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M.Tech. I Semester (HWE)	**L**	**T/P**	**C**
	0	**3**	**1.5**

(18PC2HW02) TRAFFIC ENGINEERING FIELD LABORATORY

COURSE OBJECTIVES:
- To perform traffic surveys and to retrieve different traffic stream parameters
- To analyze capacity and level of service of highways
- To design different types of parking facilities and characteristics
- To assess driver characteristics and pollution parameters due to traffic

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Understand the data collection procedure for traffic volume, speed, headway, gap acceptance behavior and parking surveys
CO-2: Knowledge of different level of service and capacity estimation
CO-3: Appreciate the driver characteristics and reaction time
CO-4: Realize pollutants emitted by vehicles and their standards

CYCLE - I
1. Classification of Traffic Volume at Mid-Block and Intersections.
2. Speed Studies analysis.
3. Headway studies: Time and Space diagrams – Car following method.
4. Gap acceptance studies.
5. Travel Time and Delay Studies by Floating Car Method at Mid Block.
6. Intersection delay studies at Uncontrolled and Signalized Intersection.
7. Parking surveys: Parking Inventory and Turnover Studies.

CYCLE - II
1. Measurement of driver characteristics: Reaction Testing, Action Judgment Testing.
2. Evaluation of driver Knowledge for Traffic Rules, Traffic Signs & Road Markings.
3. Highway Capacity Estimation.
4. Traffic Noise Measurement – Noise Contour
5. Analysis of Vehicular Pollutants from Exhaust Gases – 5 Gas Analyzer (CO2, CO, NOx, HC & O2).

TEXT BOOKS:
1. Transportation Engineering: An Introduction, Jotin and, B. Kent Lall, 3rd Edition, Prentice Hall, 2002
2. Introduction to Traffic Engineering: Manual F/data Collect & Analysis, Currin, CL Engineering, 2nd Edition, 2012
3. Traffic Engineering and Transportation Planning, L. R. Kadiyali, Khanna Publishers, 2011

REFERENCES:
1. Traffic Engineering: Theory and Practice, Pignataro L. J., Prentice Hall, Inc, 1973
2. Traffic Engineering, Roger P. Roess Elena S. Prassas and William R. McShane, Prentice Hall, 4th Edition, 2010
3. Indo – HCM, CSIR-CRRI, 2017 New Delhi

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M.Tech. I Semester (HWE)	**L**	**T/P**	**C**
	0	**4**	**2**

(18PW4HW01) TECHNICAL SEMINAR

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Identify a research topic related to advanced/state-of-the-art technologies
CO-2: Collect the literature and comprehend/analyze critically the technological advancements
CO-3: Engage in effective oral communication through presentation of seminar
CO-4: Engage in effective written communication through report

COURSE OUTLINE:

- A student shall present a seminar on a technical topic during I semester of the M.Tech. programme.
- A student, under the supervision of a faculty member, shall collect literature on a technical topic of his / her choice, critically review the literature and submit it to the Seminar Review Committee (SRC) in a prescribed report form.
- The SRC shall consist of Head of the Department, faculty supervisor and a senior faculty member of the specialization / department.
- Student shall make an oral presentation before the SRC after clearing the plagiarism check.
- Prior to the submission of seminar report to the SRC, its soft copy shall be submitted to the PG Coordinator for PLAGIARISM check.
- The report shall be accepted for submission to the SRC only upon meeting the prescribed similarity index.

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M.Tech. I Semester (HWE)	**L**	**T/P**	**C**
	2	**0**	**0**

(18AU5CS01) RESEARCH METHODOLOGY AND IPR

COURSE PRE-REQUISITES: None

COURSE OBJECTIVES:
- To introduce the characteristics of a good research problem
- To choose appropriate approaches of investigation of solutions for research problem
- To familiarize with basic Intellectual Property Rights
- To understand different Patent Rights

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Understand research problem formulation, analyze research related information and follow research ethics
CO-2: Realize the importance of ideas, concept, and creativity in the present-day context
CO-3: Recognize that when IPR would take such important place in growth of individuals and nation, it is needless to emphasize the need of information about IPR to be promoted among students in general and engineering in particular
CO-4: Appreciate IPR protection which leads to creation of new and better products, and in turn brings about, economic growth and social benefits

UNIT-I:
Introduction: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.
Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations.

UNIT-II:
Literature Survey: Effective literature studies approaches, analysis. Plagiarism, Research ethics.

UNIT-III:
Effective Technical Writing: How to write report, Paper. Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

UNIT-IV:
Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of
Patenting and Development: technological research, innovation, patenting, development.
International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT-V:
Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

UNIT-VI:
New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR.

TEXT BOOKS:
1. Research Methodology: An Introduction for Science & Engineering Students, Stuart Melville and Wayne Goddard

2. Research Methodology: An Introduction, Wayne Goddard and Stuart Melville
3. Resisting Intellectual Property, Halbert, Taylor & Francis Ltd., 2007

REFERENCES:

1. Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar, 2nd Edition
2. Research Methodology: Methods and Techniques, C. R. Kothari and Gaurav Garg, New Age International Publishers
3. Intellectual Property in New Technological Age, Robert P. Merges, Peter S. Menell, Mark A. Lemley, 2016
4. Intellectual Property Rights Under WTO, T. Ramappa, S. Chand, 2008

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M.Tech. II Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18PC1HW04) PAVEMENT ANALYSIS AND DESIGN

COURSE OBJECTIVES:

- To understand the basic modeling concepts used to analyze flexible and rigid pavements
- To appreciate pavement management concepts to better manage road pavement
- To apply the various types of highway appurtenance to enhance the safety of motorists
- To learn on rigid pavement design components

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Understand the design factors flexible and rigid pavements
CO-2: Explain the assumptions in pavement layers and carryout design of flexible and rigid pavement
CO-3: Discriminate different methods of flexible pavement design
CO-4: Appraise rigid pavement design process

UNIT-I:
Introduction: Road Pavements and pavement layers - types, functions, choice Factors affecting design, loads – axle load distribution, ESWL, EWL, VDF due to varying loads.

UNIT-II:
Stresses and Deflection / Strain in Flexible Pavements: Application of elastic theory, stresses, deflections / strains in single, two layer and multi-layer system, Applications in pavement design, KENLAYER.

UNIT-III:
Flexible Pavement Design: Empirical, semi empirical and theoretical design approaches, principle, advantages and application. Outline of other common design methods such as AASHTO and Asphalt Institute methods. Mechanistic-Empirical Pavement Design Guide - I (MEPDG).

UNIT-IV:
Stresses in Rigid Pavements: Types of stresses and causes; Introduction to Westergaard's equation for calculation of stresses in rigid pavements due to wheel loads and temperature; Considerations in rigid pavement analysis, wheel load stresses, warping stresses, frictional stresses, combined stresses, KENSLAB.

UNIT-V:
Rigid Pavement Design: Design of cement concrete pavements for highways; PCA and AASHTO Methods: Design of joints, reinforcements, tie bars, dowel bars and slab thickness as per IRC guidelines. Design features of continuously reinforced concrete pavements. Mechanistic-Empirical Pavement Design Guide - II (MEPDG).

UNIT-VI:
Design of Pavement Drainage: Detrimental effects of water, methods for controlling water in pavements. Drainage materials: aggregates, geo-textiles, pipes. Estimation of inflow, determination of drainage capacity

TEXT BOOKS:

1. Pavement Design and Materials, Papagiannakis A. T. and E. A. Masad, John Wiley and Sons, New Jersey, USA, 2008
2. Pavement Analysis and Design, Huang Y. H., Second Edition, Dorling Kindersley (India) Pvt. Ltd., New Delhi, India, 2008
3. Asphalt Institute. Thickness Design – Asphalt Pavements for Highways and Streets Manual Series No. (MS-1), Asphalt Institute, Kentucky, USA, 1999

REFERENCES:

1. The Design and Performance of Road Pavements, Croney D. and P. Croney, McGraw-Hill Book Company, London, UK, 1991
2. Mechanistic-Empirical Pavement Design Guide, A Manual of Practice, Interim Edition, Publication Code: MEPDG-1, American Association of State Highway and Transportation Officials (AASHTO), July 2008
3. IRC: 37-2017 Guidelines for the Design of Flexible Pavements, The Indian Roads Congress, New Delhi, India, 2017
4. IRC:58-2011 Guidelines for the Design of Plain Jointed Rigid Pavements for Highways, The Indian Roads Congress, New Delhi, India, 2011
5. Ministry of Road Transport and Highways, Specifications for Road and Bridge Works, Fifth Edition, Indian Roads Congress, New Delhi, India, 2013

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M.Tech. II Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18PC1HW05) HIGHWAY PROJECT FORMULATION AND ECONOMICS

COURSE OBJECTIVES:

- To introduce to economic evaluation concepts, preparation of detailed project report
- To formulate in understanding and computation of road user cost for evaluation of highway projects
- To analyze basic methods of economic analysis carried for transportation engineering projects
- To recognize the importance of EIA for transportation engineering projects

COURSE OUTCOMES: After completion of the course, students should be able to

CO-1: Classify the requirements in project formulation, Non-monetary and monetary, development of cash flow diagrams, Preparation of Project and components in Highway Planning

CO-2: Fundamental knowledge calculation of road user costs methodologies for economic evaluation of accidents

CO-3: Estimate transportation project feasibility using economic methods

CO-4: Explain factors environmental impact assessment for highway projects

UNIT-I:

Project Formulation: Requirements in project formulation; Non-monetary and monetary Criteria in formulation of project- Preparation of DPR – Guidelines- Development of cash flow diagrams; Cost and benefit components; Discounting criteria.

UNIT-II:

Project Planning: Highway Planning importance; Road Network project development; need for economic evaluation; principles of economic evaluation- welfare economics; social costs, vest charge.

UNIT-III:

Highway Economics Parameters: Road user costs – Issues in travel time savings - concept and evaluation of travel time savings; Vehicle operating costs: components of VOC, road user cost study in India; Accident costs: Methodologies for economic evaluation of an accident; Basic methods of economic analysis.

UNIT-IV:

Methods of Economics Evaluation: Basic methods of economic analysis: Equivalent Uniform Annual Cost Method; Present worth of cost method; Equivalent uniform annual net return method; Net present value method; Benefit cost ratio method; Rate of Return Method-Applications of these methods in highway projects.

UNIT-V:

Highway Finance: Project appraisal by shadow pricing with case studies; Financial analysis; Budgeting; Toll system analysis.

UNIT-VI

Environmental Impact Assessment: Basic Concepts of EIA, objectives, transportation related environmental impacts – vehicular impacts – safety impacts – roadway impacts – construction impacts – environment audit; case studies.

TEXT BOOKS:

1. Transportation Engineering Economics, Heggie I. G., McGraw Hill, 1972

2. Economic Analysis for Highways, Winfrey R., 1st Edition, 1969
3. Traffic Engineering and Transport Planning, L. R. Kadiyali, Khanna Publishers, 2000

REFERENCES:

1. Road User Cost Study, CRRI
2. IRC: SP: 30-1993, Manual on Economic Evaluation of Highway Projects in India, IRC Publications, New Delhi
3. IRC: SP: 19; 2001, Manual for Survey, Investigation & Preparation of Road Projects, IRC Publications, New Delhi

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M.Tech. II Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18PC1HW06) ADVANCED TRAFFIC ANALYSIS

COURSE OBJECTIVES:
- To introduce students on the concepts of macroscopic and microscopic models
- To analyze intersections using shockwave and bottleneck theories
- To identify the importance and types of pedestrian facilities
- To understand the importance of simulation

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Evaluate characteristics of traffic engineering like speed, flow and density
CO-2: Analyze the intersections by understanding bottleneck and shock wave theory
CO-3: Design pedestrian facilities based on their behavior and gap acceptance studies
CO-4: Apply the concepts of simulation for solving real time traffic problems

UNIT-I:
Traffic Flow Description: Traffic Stream Characteristics and Description Using Distributions; Measurement, Microscopic and Macroscopic Study of Traffic Stream Characteristics - Flow, Speed and Concentration; Use of Counting, Interval and Translated Distributions for Describing Vehicle Arrivals, Headways, Speeds, Gaps and Lags; Fitting of Distributions, Goodness of Fit Tests

UNIT-II:
Traffic Stream Models: Fundamental Equation of Traffic Flow; Speed-Flow-Concentration Relationships, Normalized Relationship, Fluid Flow Analogy Approach; Shock Wave Theory – Flow-Density diagram use in Shockwave analysis; Use of Time-space diagram for shockwave description; Bottleneck situations and shockwaves; Traffic signal and shockwave theory; Numerical examples for application of shockwave theory; Car-Following Theory

UNIT-III:
Queuing Theory: Fundamentals of Queuing Theory - Demand Service Characteristics-Deterministic Queuing Models - Stochastic Queuing Models - Multiple Service Channels,

UNIT-IV:
Queuing Analysis: Analysis of M/M/1 system; Assumptions and Derivation of System State Equations; Application of M/M/1 analysis for parking and Toll Plazas- Numerical Examples; Analysis of D/D/1 system for delay characteristics; Traffic Signal analysis as D/D/1 system; Computation of delays and queue dissipation Time – Numerical Examples.

UNIT-V:
Pedestrian Delays and Gaps: Pedestrian Gap acceptance and delays; Concept of Blocks, Anti-blocks, Gaps and Non-Gaps; Underwood's analysis for Pedestrian Delays; Warrants for Pedestrian Crossing Facilities – Minimum Vehicular Volume Warrant, Minimum Pedestrian Volume Warrant, Maximum Pedestrian Volume Warrant.

UNIT-VI:
Simulation of Traffic: Introduction - Advantages of Simulation techniques; Steps in Simulation - Scanning techniques - Example of Simulation.

TEXT BOOKS:
1. Traffic Engineering and Transportation Planning, L. R. Kadiyali, Khanna Publishers, 2011
2. Fundamentals of Transportation Engineering, C. S. Papacostas, Prentice Hall India
3. Traffic Flow Theory: A Monograph, TRB Special Report 165

REFERENCES:

1. Principles of Highway Engineering and Traffic Analysis, F. L. Mannering & W. P. Kilareski, John Wiley
2. Traffic Flow Fundamentals, A. D. May, Prentice Hall India
3. Transport Planning and Traffic Engineering, Coleman A. O 'Flaherty, Butterworth Heinemann, 2009

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M.Tech. II Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18PE1HW06) NUMERICAL METHODS AND APPLIED STATISTICS

COURSE OBJECTIVES:
- To understand the introduction of sampling techniques
- To know Statistical distributions application in traffic engineering
- To initiate students on probability and regression, data analysis and correlation techniques for road safety
- To perform and understand the importance of statistical significance

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Apply sampling techniques knowledge in traffic street design
CO-2: Describe statistical distributions process and its application in traffic engineering
CO-3: Use fundamental of probability and regression knowledge in road safety analysis
CO-4: Importance of statistical significance is assessed for design of traffic street elements

UNIT-I:
Introduction & Sampling Techniques: Frequency distribution; Mean; Standard deviation; Standard error, Skewness; Kurtosis; Definitions and Applications; Simple random sampling; Stratified sampling; Systematic sampling; Sample Size determination; Applications in Traffic Engineering,

UNIT-II:
Statistical Distributions: Binomial, Poisson, Exponential and Normal distributions; Fitting of distributions; Mean and variance; Chi-square test of goodness-of-fit; Applications in Traffic Engineering.

UNIT-III:
Probability: Laws of Probability; Conditional probability and Independent events; Laws of expectation.
Regression and Correlation: Linear regression and correlation; Multiple correlation; Multiple correlation coefficient; Standard error of estimate; Analysis of Variance; Curvilinear regression; Applications in Transportation Engineering.

UNIT-IV:
Statistical Data Analysis - Types of Data: Basic vectors and matrices; Simple estimate of centroid, Standard deviation, Dispersion, Variance and covariance; Correlation matrices; Principal component analysis; Time series analysis.
Exact Sampling Distributions: Chi-square distribution; Students T-distribution; Snedectors F-distribution.

UNIT-V:
Tests of Significance & Confidence Interval - I: Large sample and small sample tests; Tests for single mean, Means of two samples, Proportions, two variances, two observed correlation coefficients, paired T-tests, Applications.

UNIT-VI:
Tests of Significance & Confidence Interval - II: Intervals for mean, variance and regression coefficients; Applications in Traffic Engineering problems.

TEXT BOOKS:
1. Numerical Methods for Scientific and Engineering Computations, M. K. Jain, S. R. K. Iyengar and R. K. Jain., Wiley Eastern Limited, 2001

2. Introduction Methods of Numerical Analysis, S. S. Sastry, Prentice Hall of India,1998
3. Applied Numerical Analysis, Gerald C. F. and Wheatley P.O., 5th Edition, Addison-Wesley, Singapore, 1998

REFERENCES:

1. Numerical Methods for Engineers with Personal Computer Applications, Charpa S. C. and Canale R. P., McGraw-Hill
2. Probability Concepts in Engineering, Planning and Design, Vol. I & II, Alfredo H. S., Wilson H. Tang, Wiley, New York, 1975
3. Probability Statistics and Decision for Civil Engineers, Benjamin J. R. and Cornell, C. A., McGraw Hill, New York, 1975
4. Fundamentals of Mathematical Statistics, Gupta S. C. and Kapoor, K. V. Sultan Chand

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M.Tech. II Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18PE1HW07) COMPUTATIONAL TECHNIQUES IN HIGHWAY ENGINEERING

COURSE OBJECTIVES:
- To understand Simulation techniques
- To evaluate Simulation techniques
- To learn Queuing Theory for highway engineering
- To appreciate Soft Computing Techniques

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Identify Simulation techniques
CO-2: Evaluate Simulation techniques
CO-3: Appraise Queuing theory
CO-4: Relate Soft Computing Techniques for highways

UNIT-I:
Modeling and Simulation: Model classification: Mathematical, Physical and Analog models. Steps involved in simulation, Monte Carlo Simulation, Model Validation and verification of simulation models. Continuous and Discrete Models, Model Calibration and Model Validation.

UNIT-II:
Sampling Techniques: Frequency distribution, mean, standard deviation, standard error, Skewness, Kurtosis, Definitions and applications; Simple random sampling, stratified sampling, systematic sampling, sample size determination, Applications in Traffic engineering;

UNIT-III:
Data Analysis Using Different Distributions: Binomial, Poisson, Exponential and Normal distributions; Fitting of distributions, Mean and variance, Chi-square test of goodness-of-fit, Chi-square distribution, Students T-distribution, Snedectors F-distribution.

UNIT-IV:
Service Rate Analysis: General Structure, operating characteristics, deterministic queuing model, probabilistic queuing models and simulation of queuing systems.

UNIT-V:
Multivariate Data Analysis: Vectors and Matrices, Simple estimate of centroid, standard deviation, dispersion, variance and co-variance, correlation matrices, Principal Component Analysis.
Forecasting Models: Moving averages, exponential smoothening, trend projections, causal models, time series analysis of vehicle growth and road traffic crashes.

UNIT-VI:
Soft Computing Techniques: Artificial Neural Networks – Basic concepts, neural architecture and examples. Support Vector Machines – Basic concepts, classification and support vector regression, concepts of kernels, basics of optimization programming.

TEXT BOOKS:
1. Multivariate Data Analysis, Hair J. and Anderson R., 2010
2. Applied Multivariate Statistical Analysis, Johnson R. A. and Wichern D. W., 2003
3. Support Vector Machines for Pattern Classification, S. Abe, 2005

REFERENCES:

1. Fundamentals of Mathematical Statistics, Gupta S. C. and Kapoor K. V., Sultan Chand
2. Multivariate Data Analysis, Cootey W. W. & Cohens P. R., John Wiley & Sons
3. Probability Concepts in Engineering, Planning and Design, Vol. I & II, Alfredo H. S., Wilson H. Tang, Wiley International

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M.Tech. II Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18PE1HW08) HIGHWAY NETWORK ANALYSIS AND OPTIMIZATION TECHNIQUES

COURSE OBJECTIVES:
- To learn the importance of network flows
- To explain shortest path of algorithms
- To reveal Minimum cost network assignment
- To understand designs concepts highway network applications

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Assess how network flows
CO-2: Understands different types shortest path of algorithms
CO-3: Perform Minimum cost network assignment
CO-4: Explains the different types highway network applications

UNIT-I:
Network Flows: Applications, definitions, graphs, paths, trees, cycles, loops, walk, network representation (adjacency list and matrices) and basic network transformations.

UNIT-II:
Network Algorithms: Algorithms; Complexity, Search Algorithms, Strategies for designing polynomial algorithms.

UNIT-III:
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.

UNIT-IV:
Minimum Cost Network Assignment: Optimality conditions, cycle-cancelling algorithm, Successive shortest path algorithm, other polynomial time variants.

UNIT-V:
Network Equilibrium Analysis: Principles and optimization formulations, Frank-Wolfe algorithm; Special cases and variants.

UNIT-VI:
Highway Network 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, project scheduling, reliability of distribution systems, telecommunication/power networks etc.

TEXT BOOKS:
1. Network Flows: Theory, Algorithms and Application, Ahuja R., Magnanti T. L. and Orlin J. B., Prentice Hall, New Jersey, 1993
2. Transportation Networks, Bell M. G., Elsevier Science Publishers, 1999
3. Optimization Methods in System Analysis and Operations Research, K. V. Mittal and C. Mohan., 1996

REFERENCES:

1. Introduction to Optimization, J. C. Pant, Jain Brothers, New Delhi
2. Optimisation Theory and Applications, S. S. Rao, Wiley Eastern Ltd., New Delhi
3. Optimization Method, K. V. Mittal, Wiley Eastern Ltd. New Delhi
4. Operations Research: An Introduction, H. A. Taha, MacMillan Pub Co., New York, 2013

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M.Tech. II Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18PE1GT01) SOIL STRUCTURE INTERACTION

COURSE OBJECTIVES:
- To introduce the concepts and terminology of soil structure interaction
- To analyze different type of framed structures resting on natural deposits
- To develop a knowledge on behavior of piles and pile groups on soils
- To create and formulate advance programming to solve interaction problems

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Evaluate soil structure interaction for different types of structure under various conditions of loading and subsoil characteristics
CO-2: Prepare comprehensive design-oriented computer programs for interaction problems based on theory of sub grade reaction such as beams, footings, rafts etc.
CO-3: Analyze different types of frame structure founded on stratified natural deposits with Linear and non-linear stress-strain characteristics
CO-4: Understand action of group of piles considering stress-strain characteristics of real soils

UNIT-I:
Importance of Soil Structure Interaction: Critical Study of Conventional Methods of Foundation design, Nature and Complexities of Soil Structure Interaction.

UNIT-II:
Numerical Techniques in SSI: Application of Advanced Techniques of Analysis such as FEM and Finite Difference Method

UNIT-III:
Relaxation and Interaction Studies: Relaxation and Interaction for the Evaluation of Soil Structure Interaction for Different Types of Structure under various Conditions of Loading and Subsoil Characteristics.

UNIT-IV:
Simulation Program: Effect of seismic load on structure interaction, Preparation of Comprehensive Design Oriented Computer Programs for simple seismic soil structure interaction model, Interaction of Beams, Footings, Rafts Etc. based on Sub Grade Reaction.

UNIT-V:
Soil Structure Interaction of Framed Structure: Analysis of Different Types of Framed Structures Founded on Stratified Natural Deposits with Linear and Non-Linear Stress- Strain Characteristics.

UNIT-VI:
Analysis of Laterally and Axially Loaded Pile Groups: Determination of Pile Capacities and Negative Skin Friction, Action of Group of Piles considering Stress-Strain Characteristics of Real Soils, Anchor Piles and Determination of Pullout Resistance.

TEXT BOOKS:
1. Analytical and Computer Methods in Foundation, Bowels J. E., McGraw-Hill, New York, 1974
2. Elastic Analysis of Soil-Foundation Interaction, Selvadurai A. P. S., Elsevier Scientific Publishing

REFERENCES:

1. Numerical Methods in Geotechnical Engineering, Desai C. S. and Christian J. T., McGraw-Hill., New York
2. Soil Structure Interaction - The Real Behaviour of Structures, Institution of Structural Engineers
3. Elastic Analysis of Soil Foundation Interaction, Developments in Geotechnical Engineering, Vol-17, Elsevier Scientific Publishing Company
4. Analysis & Design of Substructures, Swami Saran, Oxford & IBH Publishing Co. Pvt. Ltd.

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M.Tech. II Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18PE1HW09) PAVEMENT MANAGEMENT SYSTEMS

COURSE OBJECTIVES:
- To understand Network level and project level PMS
- To evaluate Pavements on Functional and Structural basis
- To learn Alternative design strategies of pavements and Economic evaluation
- To appreciate the role of Expert System in PMS

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Identify and select the various Design strategies of pavement using PMS concept
CO-2: Evaluate the pavement condition using Functional and Structural Evaluation techniques.
CO-3: Appraise and Estimate the life cycle cost of Pavement
CO-4: Relate ANN and Fuzzy concepts for PMS

UNIT-I:
Introduction: Definition -Components of Pavement Management Systems, Essential features Pavement Management Levels and functions: Ideal PMS- Network and Project levels of PMS Influence Levels- PMS Functions- Function of Pavement evaluation

UNIT-II:
Pavement Performance: Serviceability Concepts- roughness- Roughness Components Equipment -IRI -modeling techniques, structural condition deterioration models, mechanistic and empirical models, HDM and other models, comparison of different deterioration models.

UNIT-III:
Functional and Structural Evaluation: Functional and Structural deterioration models, unevenness prediction models and other models, comparison.

UNIT-IV:
Rehabilitation process for rigid pavements, for flexible pavements, rehabilitation alternative and condition survey.

UNIT-V:
Design Alternatives and Selection: design objectives and constraints, basic structural response models, physical design inputs, alternate pavement design strategies and economic evaluation, life cycle costing, analysis of alternate pavement strategies based on distress and performance, case studies. Equipments

UNIT-VI:
Expert Systems and Pavement Management: Role of computers in pavement management, applications of expert systems for managing pavements, expert system for pavement evaluation and rehabilitation, knowledge-based expert systems.

TEXT BOOKS:
1. Pavement Management System, Ralph Haas and Ronald W. Hudson, McGraw-Hill, 1978
2. Modern Pavement Management, Haas R. W. R. Hidson and J. P. Zaniewski, Krieger Publishing Company, Florida, 1994
3. Pavement Management for Airports, Roads and Parking Lots, Mo Y. Shahin, Second Edition, Springer, 2005

REFERENCES:

1. Infrastructure Management: Integrating Design, Construction, Maintenance, Rehabilitation, and Renovation, Hudson W. R., R. Haas and W. Uddin, McGraw-Hill, New York, 1997
2. Proceedings of North American Conference on Managing Pavement
3. Proceedings of International Conference on Structural Design of Asphalt Pavements NCHRP, TRR and TRB Special Reports
4. Pavement Analysis and Design, Huang Yang H., Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1993

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M.Tech. II Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18PE1HW10) MASS TRANSPORTATION SYSTEM AND PLANNING

COURSE OBJECTIVES:

- To understand and apply basic concepts and methods of Mass transportation system and planning in India
- To learn Transit system, types of transit modes, characteristics of transit system for understanding transit system and estimation of transit demand based on origin and destination surveys
- To understand and be able to apply bus route network planning and route system
- To understand Mass transit corridor identification and planning

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Identify various Mass transport system and their characteristics
CO-2: Asses public transport and development strategies
CO-3: Planning of mass transit systems
CO-4: Evaluation of transit performance and its impact on network analysis

UNIT-I:
Transit System and Issues: Introduction to Mass Transport – Role of various modes of Mass Transport – Problems and their Impact – System Characteristics: 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 Transport System Performance at National, State, Local and International levels

UNIT-II:
Public Transit System: Urban Transport System – Public Transport System Re-genesis and Technology – Physical performance of Public Transport System – Public Transport and Urban Development Strategies - Characteristics of Rail Transit – Vehicle Characteristics, ITS, Para transit systems – Intermediate Public Transport.

UNIT-III:
Mass Transit Corridor Identification & Planning: Corridor identification – Network Compression Method - Planning of Rapid Transit System - System Selection - Supporting and Enclosing Structures - System Evaluation - Track Structures - Power Supply and Distribution - Signal System – Aesthetics and Noise Consideration - Cost of Construction - Station Arrangements - Platform Capacity - Fare Collection, Transit Marketing.

UNIT-IV:
Bus Transit Planning and Scheduling: Route Location, Route Structure, Route Coding Techniques, Route Capacity - Planning of Transit Network - Different Types - Service Area Coverage - Evaluation - Selection of Optimal Network - Path Building Criteria - Route Planning and Scheduling – Bus Transport System – Performance and Evaluation – Scheduling – Conceptual patterns of bus service – Network Planning and Analysis – Bus Transport System Pricing – Bus Transit System Integration – Analytical Tools and Techniques for Operation and Management – Bus Rapid Transit Systems.

UNIT-V:
Rail Transit Terminals and Performance Evaluation: Performance Evaluation – Efficiency, Capacity, Productivity and Utilization – Performance Evaluation Techniques and Application – System Network Performance – Transit Terminal Planning and Design Urban Rail Transit

Planning – MRTS – LRTS, Metro Rail – Monorail – Network Design, Capacity and Traffic Fore casting

UNIT-VI:

Impact of Transit: Policies and Strategies for Mass Transport – Need for Integrated Approach – Unified Transport Authorities – Institutional arrangement – Urban Transport Fund – Parking Policies - Private Sector in Mass Transport – Bus and Rail Integration – Co-ordination of Feeder Services – Transit Oriented Land Use Development – Case Studies - Urban Transportation and Land use – Impact of Transport Development on Environment – Remedial measures – Policy Decisions – Recent Trends in Mass Transportation Planning and Management.

TEXT BOOKS:

1. Urban Mass Transport Planning, Black, McGraw-Hill
2. Urban Public Transport System and Technology, V. R. Vuchic, Prentice-Hall Inc.
3. Fundamentals of Transportation Engineering, C. S. Papacostas, Prentice-Hall India

REFERENCES:

1. Public Transport Planning Operation and Management, G. E. Gray and C. A. Hoel, Prentice Hall
2. Planning for Public Transport, White P. R., UCL Press Ltd.

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M.Tech. II Semester (HWE)	**L**	**T/P**	**C**
	0	**3**	**1.5**

(18PC2HW03) HIGHWAY MATERIAL CHARACTERIZATION AND TRAFFIC SIMULATION LABORATORY

COURSE OBJECTIVES:
- To understand and apply basic concepts for pavement evaluation techniques
- To learn binder performance characteristics
- To design bituminous mix characteristics using resilient and rutting parameters
- To assess, plan, develop un-signalised and signalised intersections using simulation techniques

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Identify different pavement evaluation techniques
CO-2: Understand various aging tests on bitumen for performance of binder
CO-3: Knowledge performance bituminous mixes from rutting and stiffness parameters
CO-4: Evaluation of signalized and unsignalized intersections using simulation techniques

CYCLE I
Tests on Functional & Structural Characteristics Pavement:
a) Road Roughness survey – MERLIN.
b) Pavement evaluation using DCP, PLWD & BBD Techniques.
c) Aggregate Polishing Value and Skid Resistance.

CYCLE II
Bitumen & Bituminous Mix Performance:
a) Kinematic viscosity using Rotational Viscometer.
b) Long Term Ageing.
c) Short Term Ageing using RTFO.
d) Loss on Heating.
e) Resilient Modulus for Bituminous Mixes.
f) Rutting and Stripping Characteristics for Bituminous Mixes.

CYCLE III
Traffic Simulation: Simulation analysis for controlled & uncontrolled intersection using VISSIM.

TEXT BOOKS:
1. Highway Materials and Pavement Testing, Khanna S. K., Justo C. E. G., and A. Veeraragavan, 5th Edition, Nem Chand and Brothers, Roorkee, India, 2009
2. Pavement Analysis and Design, Huang Y. H., Pearson Prentice Hall, New Jersey, USA, 2004
3. Pavement Design and Materials, A. T. Papagiannaki's and E. A. Masad, John Wiley & Sons, 2008

REFERENCES:
1. Relevant IS, IRC, ASTM Codes

Note: All laboratory tests are as per IS, ASTM, AASHTO, TRL, IRC, BS procedures / specifications and guidelines

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M.Tech. II Semester (HWE)	**L**	**T/P**	**C**
	0	**3**	**1.5**

(18PC2HW04) HIGHWAY NUMERICAL ANALYSIS LABORATORY

COURSE OBJECTIVES:
- Understand the introduction of sampling techniques
- Knowledge on statistical distributions application in traffic engineering
- Learn probability and regression, data analysis and correlation techniques for road safety
- Perform different statistical measures for assessing model significance

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Apply sampling techniques in traffic stream design
CO-2: Relate statistical distributions process and its application in traffic engineering
CO-3: Analyze road safety using probability and regression techniques
CO-4: Understand statistical significance for design of traffic stream elements

CYCLE I
1. Random Numerical Sampling
2. Fitting Binomial, Normal and Poisson distribution
3. Time Series Analysis and Traffic Forecasting as per IRC 108 – 1996
4. Road Traffic Crashes with Geometrical Parameter and Skid Relationships

CYCLE II
5. Multivariate Data Analysis
6. Linear and Generalized Models Calibration
7. Analysis of Noise/Air pollution related Transport Problems
8. Validation and Determining Goodness of Fit, Chi-Square, T-Tests and Other Measures of Fit
9. Application of Soft Computing Techniques like Artificial Neural Network and Support Vector Machines to Transportation Problems using SPSS and R software

CYCLE III
10. Basics of Transportation Software's (Demo) – Mx Road and QGIS.

TEXT BOOKS:
1. Multivariate Data Analysis, Hair J., and Anderson R., 2010
2. Applied Multivariate Statistical Analysis, Johnson R. A. and Wichern D. W., 2003
3. Support Vector Machines for Pattern Classification, S. Abe, 2005

REFERENCES:
1. Fundamentals of Mathematical Statistics, Gupta S. C. and Kapoor K. V., Sultan Chand
2. Multivariate Data Analysis, Cootey W. W. & Cohens P. R., John Wiley & Sons
3. Probability Concepts in Engineering, Planning and Design, Vol. I & II, Alfredo H. S., Wilson H. Tang, Wiley International

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M.Tech. II Semester (HWE)	**L**	**T/P**	**C**
	0	**4**	**2**

(18PW4HW02) MINI-PROJECT

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Understand the formulated industry / technical / societal problems
CO-2: Analyze and / or develop models for providing solution to industry / technical / societal problems
CO-3: Interpret and arrive at conclusions from the project carried out
CO-4: Demonstrate effective communication skills through oral presentation
CO-5: Engage in effective written communication through project report

COURSE OUTLINE:

- A student shall undergo a mini-project during II semester of the M.Tech. programme.
- A student, under the supervision of a faculty member, shall collect literature on an allotted project topic of his / her choice, critically review the literature, carry out the mini-project, submit it to the department in a prescribed report form.
- Evaluation of the mini-project shall be done by a Project Review Committee (PRC) consisting of the Head of the Department, faculty supervisor and a senior faculty member of the specialization / department.
- Prior to the submission of mini-project report to the PRC, its soft copy shall be submitted to the PG Coordinator for PLAGIARISM check.
- The mini-project report shall be accepted for submission to the PRC only upon meeting the prescribed similarity index.

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M.Tech. II Semester (HWE)	**L**	**T/P**	**C**
	2	**0**	**0**

(18AU5EN01) ENGLISH FOR ACADEMIC AND RESEARCH WRITING

COURSE OBJECTIVES:

- To understand the usage of appropriate vocabulary (Formal, Informal, Gender Insensitive etc.)
- To understand the features and processes of academic writing
- To identify the resources
- To understand standard documentation styles

COURSE OUTCOMES: After completion of the course, students should be able to

CO-1: Use appropriate vocabulary (Formal, Informal, Slang, Gender Insensitive etc.)

CO-2: Employ processes of academic writing

CO-3: Identify the resources

CO-4: Understand standard documentation styles

UNIT- I:

Introduction to Research:

i. Identifying the topic
ii. Identifying Sources; Finding Sources
iii. Defining the broad area; Defining the specific area; Difference between a broad area and specific area
iv. Choosing a topic
v. Mechanics of Writing – Language, Tone, Style, Ethics

UNIT-II:

Referencing & Library Skills:

i. Literature Survey
ii. Writing Objectives
iii. Hypothesis
iv. Methodology
v. Prospects for Future Research

UNIT-III:

Academic Writing Skills:

i. Paraphrasing
ii. Summarizing
iii. Quoting
iv. Rewriting
v. Expansion

UNIT-IV:

Kinds of Academic Writing:

i. Essays
ii. Reports
iii. Reviews
iv. SOPs
v. Abstracts
vi. Proposals

UNIT-V:

Research Process:

i. Selection of Topic

ii. Formulation of Hypothesis
iii. Collection of Data
iv. Analysis of Data
v. Interpretation of Data
vi. Presentation of Data

UNIT-VI:

i. Title
ii. Abstract
iii. Introduction
iv. Literature Survey
v. Methodology
vi. Discussion
vii. Findings/Results
viii. Conclusion
ix. Documenting Sources

TEXT BOOKS:

1. Writing for Science, Goldbort R., Yale University Press (available on Google Books), 2006
2. Handbook of Writing for the Mathematical Sciences, Highman N., SIAM. Highman's Book, 1998

REFERENCES:

1. How to Write and Publish a Scientific Paper, Day R., Cambridge University Press, 2006
2. English for Writing Research Papers, Adrian Wall Work, Springer New York Dordrecht Heidelberg London, 2011
3. MLA Handbook for Research

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M.Tech. III Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18PE1HW11) HIGHWAY CONSTRUCTION AND QUALITY CONTROL

COURSE OBJECTIVES:
- To learn and define the various component of pavement structure
- To understand, design and construct various drainage systems
- To gain knowledge on various equipment's used for construction of road
- To differentiate about various construction of base course such as WMM, WBM etc.

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Recognize and select the equipment's for the construction of road
CO-2: Design and economize the various constructions of different layers such as base and sub-base course
CO-3: Identify and select the maintenance works of various components of road works
CO-4: Principle of construction planning and importance of CPM PERT

UNIT-I:
Pavement Structure: 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.

UNIT-II:
Pavement 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 for urban roads.

UNIT-III:
Road Construction Equipment: different types of excavators, graders, soil compactors / rollers, pavers and other equipment for construction of different pavement layers – their uses and choice Problem on equipment usage charges; Pre-construction surveys and marking on ground - Specifications and steps for the construction of road formation in embankment and cut, construction steps for granular sub-base, quality control tests.

UNIT-IV:
Pavements Constructions: Different types of granular base course – WMM, DBM; 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. Different types of sub-base and base course for cement concrete (CC) pavement and construction method. Construction of cement concrete (PQC) pavements joints quality control during construction. Construction details of interlocking concrete block pavements

UNIT-V:
Construction Planning: Principle of construction planning, application of CPM and PERT (Problems not included) Road maintenance works – day to day and periodic maintenance works of various components of road works and road furniture.

UNIT-VI:
Pavement Maintenance: Preparation of existing pavement – patching, profile correction, Special measures to deal with reflection cracks in pavement layers, slipperiness of surface, etc. Special problems in construction & maintenance of hill roads, land slide, causes, investigation, and preventive and remedial measures, protection of embankment and cut slopes.

TEXT BOOKS:

1. Construction Planning Equipment and Method, Peurifoy R. L. and Clifford J. S., McGraw-Hill Book Co.
2. Inc. Hot Mix Asphalt Materials, Mixture Design and Construction, Freddy L. Roberts, Prithvi S. Kandhal et al., 2nd Edition, National Asphalt Pavement Association Research and Education Foundation, Maryland, USA
3. Construction Equipment and its Management, Sharma S. C., Khanna Publishers

REFERENCES:

1. Hot Mix Asphalt Paving Handbook, National Asphalt Pavement Association, 5100 Forbes Boulevard, Lanhm, Mary Land, USA
2. MoRTH Manual for Construction and Supervision of Bituminous Works, 2013, Indian Roads Congress
3. MoRTH Manual for Maintenance of Roads, 1989, Indian Roads Congress
4. IRC: 42-1994, IRC:15-2002, IRC SP :11-1988, , 55-2001, 57-2001,58-2001, IRC 19-1977, 27-1967, 29-1988, 34-1970, 36-1970,48-1972,61-1976, 63-1976, 68-1976, 81-1997,82-1982, 84-1983,93-1985, 94-1986, 95-1987, 98-1997, 105-1988

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M.Tech. III Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18PE1HW12) EVALUATION AND STRENGTHENING OF PAVEMENTS

COURSE OBJECTIVES:
- To learn the importance of evaluation and strengthening of pavements
- To explain the stress and strains for various types of pavements and its evaluation procedures
- To reveal the structural and functional requirements of pavements along with its failures
- To understand overlay designs concepts performed through BBD and FWD

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Assess how functional and structural pavements occurs
CO-2: Understand different types of distress in pavements
CO-3: Perform BBD and FWD test for evaluation of pavements
CO-4: Explain the different types of pavement failures

UNIT-I:
Introduction: Highway and airport pavements, Types and component parts of pavements, their differences - Factors affecting design and performance of pavements.

UNIT-II:
Stresses and Deflections in Flexible Pavement: Stresses and deflections in homogeneous masses. Wheel load stresses, various factors in traffic wheel loads; ESWL and EWL factors. Pavement behavior under transient traffic loads; Factors affecting design and performance of pavements.

UNIT-III:
Stresses and Deflections in Rigid Pavement: Types of stresses and causes, factors influencing the stresses; general considerations in rigid pavement analysis, EWL, wheel load stresses, warping stresses, frictional stresses, combined stresses.

UNIT-IV:
Structural and Functional Requirements of Flexible and Rigid Pavements: Pavement distress; different types of failures & its causes – structural & functional safety – repair and retrofitting of road structures.

UNIT-V:
Evaluation of Surface Condition: Methods of measurement of skid resistance, unevenness, ruts and cracks. Pavement surface condition evaluation by physical measurements, by riding comfort and other methods; their applications.

UNIT-VI:
Evaluation of Pavement Structural Condition: Evaluation by non-destructive tests such as FWD, Benkelman Beam rebound deflection using BBD for flexible overlay design, Plate load test, wave propagation and other methods of load tests; evaluation by destructive test methods, and specimen testing.

TEXT BOOKS:
1. Principles of Pavement Design, Yoder E. J. and Witczak, 2nd Edition, John Wiley and Sons, 1975
2. The Design and Performance of Road Pavements, Croney D. and P. Croney, McGraw-Hill Book Company, London, UK, 1991
3. Textbook of Highway Engineering, Khanna and Justo, Nemchand Brothers, Roorkee, 2004

REFERENCES:

1. Pavement Management System, Haas and Hudson, McGraw-Hill Book Co., New York, 1994
2. Pavement Design and Materials, Papagiannakis A. T. and E. A. Masad, John Wiley and Sons, New Jersey, USA, 2008
3. Pavement Engineering – Principles and Practice, Mallick R. B. and T. El-Korchi, CRC Press, Taylor and Francis Group, Florida, USA, 2009

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M.Tech. III Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18PE1HW13) ADVANCED HIGHWAY MATERIALS

COURSE OBJECTIVES:
- To study the properties and test on aggregate, bituminous materials
- To understand different composites and recycled waste products used in pavement constructions
- To introduce to the principles of bituminous pavement construction
- To learn the procedure for bituminous and PCC mix design

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Understand the properties and test procedures of aggregate
CO-2: Evaluates the bituminous mix design of modified mixtures
CO-3: Assess different composites and recycled waste products in bituminous mixes
CO-4: Explains different types of bituminous pavement construction and its principles do bituminous and PCC mix design

UNIT-I:
Aggregate: Nature and properties – aggregate requirements – types and processing – aggregates for pavement base – aggregate for bituminous mixture – aggregate for Portland Cement Concrete – light weight aggregate – tests on aggregate – specification.

UNIT-II:
Bituminous Materials: conventional and modified binders – production – types and grade – physical and chemical properties and uses – types of asphalt pavement construction – principles of bituminous pavement construction – tests on bituminous materials. Bituminous Mix design – modified mixtures – temperature susceptibility and performance.

UNIT-III:
Cement /Concrete Based Materials: Cement – properties – PCC mix design and properties – modified PCC – Mix Design – Behaviour – Performance – Tests on Cement and Concrete mixes. High Performance Concrete – low shrinkage – increased strength.

UNIT-IV:
Composites, Plastics: Plastics and polymerization process – properties – durability and chemical composition – Reinforced Polymer Composites

UNIT-V:
Geo-synthetics: Properties – durability and chemical composition – Geosynthetics – Dry Powdered Polymers – Enzymes.

UNIT-VI:
Reclaimed / Recycled Waste Products: Reclaimed Materials – waste products in civil engineering applications – effect of waste products on materials, structure and properties – self healing and smart materials – locally available materials.

TEXT BOOKS:
1. Alternative Materials in Road Construction, P. T. Sherwood, Thomas Telford Publication, London, 1997
2. RRL, DSIR, Soil Mechanics for Road Engineers, HMSO, London, 1995
3. Designing with Geosynthetics, Koerner R. M., Prentice Hall, Englewood Cliffs, New Jersey, USA

REFERENCES:

1. Civil Engineering Materials, Shan Somayaji, Second Edition, Prentice Hall Inc., 2001
2. Pavement Engineering – Principles and Practice, Mallick R. B. and T. El-Korchi, CRC Press, Taylor and Francis Group, Florida, USA, 2009
3. Ministry of Road Transport and Highways, Specifications for Road and Bridge Works, Fourth Edition, Indian Roads Congress, New Delhi, India, 2001
4. Pavement Design and Materials, Papagiannakis A. T. and E. A. Masad, John Wiley and Sons, New Jersey, USA, 2008

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M.Tech. III Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18OE1CN01) BUSINESS ANALYTICS

COURSE OBJECTIVES:

- To understand the role of business analytics within an organization and to analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization
- To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making and to become familiar with processes needed to develop, report, and analyze business data
- To use decision-making tools/Operations research techniques and to manage business process using analytical and management tools
- To analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Apply knowledge of data analytics
CO-2: Think critically in making decisions based on data and deep analytics
CO-3: Use technical skills in predicative and prescriptive modeling to support business decision-making
CO-4: Translate data into clear, actionable insights

UNIT-I:
Business Analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organization, competitive advantages of Business Analytics.
Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

UNIT-II:
Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data Business Analytics Technology.

UNIT-III:
Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.
Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

UNIT-IV:
Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.
Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

UNIT-V:

Decision Analysis: Formulating Decision Problems, Decision Strategies without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.

UNIT-VI:

Recent trends in Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

TEXT BOOKS:

1. Business Analytics-Principles, Concepts, and Applications, Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press
2. Business Analytics, James Evans, Pearson Education
3. Business Analytics, Purba Halady Rao, PHI, 2013

REFERENCES:

1. Business Analytics for Managers: Taking Business Intelligence Beyond Reporting, Gert H. N. Laursen, Jesper Thorlund, 2nd Edition, Wiley Publications
2. Business Analytics: Data Analysis & Decision Making, S. Christian Albright, Wayne L. Winston 5th Edition, 2015
3. Business Intelligence Guidebook: From Data Integration to Analytics, Rick Sherman Elsevier, 2014

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M.Tech. III Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18OE1AM01) INDUSTRIAL SAFETY

COURSE PRE-REQUISITES: Elements of Mechanical, Civil, Electrical and Industrial Engineering

COURSE OBJECTIVES:

- To achieve an understanding of principles, various functions and activities of safety management
- To communicate effectively information on Health safety and environment facilitating collaboration with experts across various disciplines so as to create and execute safe methodology in complex engineering activities
- To anticipate, recognize, and evaluate hazardous conditions and practices affecting people, property and the environment, develop and evaluate appropriate strategies designed to mitigate risk
- To develop professional and ethical attitude with awareness of current legal issues by rendering expertise to wide range of industries

COURSE OUTCOMES: After completion of the course, students should be able to

CO-1: Apply risk management principles to anticipate, identify, evaluate and control physical, chemical, biological and psychosocial hazards

CO-2: Communicate effectively on health and safety matters among the employees and with society at large

CO-3: Demonstrate the use of state-of-the-art occupational health and safety practices in controlling risks of complex engineering activities and understand their limitations

CO-4: Interpret and apply legislative / Legal requirements, industry standards, and best practices in accident prevention programmes in a variety of workplaces

UNIT-I:

Safety Management: Evaluation of modern safety concepts – Safety management functions – safety organization, safety department – safety committee, safety audit - performance measurements and motivation – employee participation in safety and productivity.

UNIT-II:

Operational Safety: Hot metal Operation – Boiler, pressure vessels – heat treatment shop - gas furnace operation-electroplating-hot bending pipes – Safety in welding and cutting. Cold-metal Operation- Safety in Machine shop-Cold bending and chamfering of pipes – metal cutting – shot blasting, grinding, painting – power press and other machines

UNIT-III:

Safety Measures: Layout design and material handling - Use of electricity – Management of toxic gases and chemicals – Industrial fires and prevention – Road safety– Safety of sewage disposal and cleaning – Control of environmental pollution – Managing emergencies in industrial hazards.

UNIT-IV:

Accident Prevention: Human side of safety – personal protective equipment – Causes and cost of accidents. Accident prevention programmes - Specific hazard control strategies - HAZOP – Training and development of employees – First Aid – Firefighting devices – Accident reporting investigation.

UNIT-V:

Safety, Health, Welfare and Laws: Safety and health standards – Industrial hygiene – occupational diseases prevention - Welfare facilities – History of legislations related to safety–

pressure vessel act- Indian boiler act- The environmental protection act – Electricity act - Explosive act.

UNIT-VI:

Safe Handling and Storage: Material Handling, Compressed Gas Cylinders, Corrosive Substances, Hydrocarbons, Waste Drums and Containers

TEXT BOOKS:

1. Safety Management, John V. Grimaldi and Rollin H. Simonds, All India Travellers Bookseller, New Delhi, 1989
2. Safety Management in Industry, Krishnan N. V., Jaico Publishing House, 1996

REFERENCES:

1. Occupational Safety Manual, BHEL
2. Industrial Safety and The Law, P. M. C. Nair Publisher's, Trivandrum
3. Managing Emergencies in Industries, Loss Prevention of India Ltd., Proceedings, 1999
4. Safety Security and Risk Management, U. K. Singh & J. M. Dewan, A. P. H. Publishing Company, New Delhi, 1996
5. Industrial Safety Management: Hazard Identification and Risk Control, L. M. Deshmukh, McGraw-Hill Education (India) Private Limited, 2005

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M.Tech. III Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18OE1AM02) OPERATIONS RESEARCH

COURSE PRE-REQUISITES: Mathematics, Industrial Engineering

COURSE OBJECTIVES:
- To analyze linear programming models in practical and their practical use
- To apply the transportation, assignment and sequencing models and their solution methodology for solving problems
- To apply the theory of games, replacement, inventory and queuing models and their solution methodology for solving problems
- To evaluate the dynamic programming and simulation models

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Apply and solve the dynamic programming problems
CO-2: Apply the concept of non-linear programming
CO-3: Carry out sensitivity analysis
CO-4: Model the real-world problem and simulate it

UNIT-I:
Introduction to Operations Research-Definitions of OR, Characteristics of OR, Scope of OR, Classification of Optimization Techniques, models in OR, General L.P Formulation, Graphical solution, Simplex Techniques.

UNIT-II:
Revised simplex method - duality theory - dual simplex method – sensitivity or post optimality analysis - parametric programming

UNIT-III:
Nonlinear programming problem - Kuhn-Tucker condition, min cost flow problem - max flow problem - CPM/PERT

UNIT-IV:
Scheduling and sequencing, Inventory models, deterministic inventory, models - Probabilistic inventory control models - Geometric Programming.

UNIT-V:
Waiting line Models, Single and Multi-channel Problems, Dynamic Programming, Game Theory, Simulation.

UNIT-VI:
Introduction to Genetic Algorithms, Operators, applications to engineering optimization, Problems.

TEXT BOOKS:
1. Operations Research, S. D. Sharma, Kedarnath Ramnath, Meerut, New Delhi
2. Engineering Optimization, S. S. Rao, New Age International Publications, 2014
3. Introduction to Genetic Algorithms, S. N. Sivanandam, Springer

REFERENCES:
1. Operations Research-An Introduction, H. A. Taha, PHI, 2008
2. Principles of Operations Research, H. M. Wagner, PHI, Delhi, 1982
3. Introduction to Optimization: Operations Research, J. C. Pant, Jain Brothers, Delhi, 2008

4. Operations Research, Hitler Liebermann McGraw-Hill, 2009
5. Operations Research, Pannerselvam, Prentice Hall of India, 2010

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M.Tech. III Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18OE1AM03) COMPOSITE MATERIALS

COURSE PRE-REQUISITES: Maths, Physics, Chemistry, Engineering Mechanics, Mechanics of Solids

COURSE OBJECTIVES:
- To understand composite materials and their properties, relationship between them and manufacturing methods
- To understand the principles of material science applied to composite materials
- To study the equations to analyze problems by making good assumptions and learn systematic engineering methods to solve practical composite mechanics problems

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Apply fundamental knowledge of mathematics to modeling and analysis of composite materials
CO-2: Understand the manufacturing methods of various composite materials
CO-3: Analyze the failure modes of composites

UNIT-I:
Introduction: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT-II:
Reinforcements: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements.
Mechanical Behavior of Composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

UNIT-III:
Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications.
Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

UNIT-IV:
Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications, Introduction to Machining of Composites.

UNIT-V:
Elastic Behavior of Laminate: Basic assumptions, Strain-displacement relations, Stress-strain relation of layer within a laminate, Force and moment resultant, General load–deformation relations, Analysis of different types of laminates

UNIT-VI:
Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first ply failure-insight

strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TEXT BOOKS:

1. Material Science and Technology, Vol. 13–Composites, R. W. Cahn – VCH, West Germany
2. Analysis and Performance of Fiber Composites, Third Edition, B. D. Agarwal, Wiley Publishers

REFERENCES:

1. Mechanics of Composite Materials, Second Edition. Robert M. Jones, Scripta Book Company
2. Materials Science and Engineering-An Introduction, W. D. Callister Jr., Adapted by R. Bala Subramaniam, John Wiley & Sons, NY, Indian Edition, 2007
3. Composite Materials, K. K. Chawla
4. Composite Materials Science and Applications, Deborah D. L. Chung
5. Composite Materials Design and Applications, Danial Gay, Suong V. Hoa and Stephen W. Tasi

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M.Tech. III Semester (HWE)	**L**	**T/P**	**C**
	3	**0**	**3**

(18OE1PS01) WASTE TO ENERGY

COURSE PRE-REQUISITES: None

COURSE OBJECTIVES:
- To create awareness in students of energy conservation
- To identify the use of different types of Bio waste energy resources
- To understand different types of bio waste energy conservations
- To detect different waste conversion into different forms of energy

COURSE OUTCOMES: After completion of the course, students should be able to
CO1: Find different types of energy from waste to produce electrical power
CO2: Estimate the use of bio waste to produce electrical energy
CO3: Understand different types of bio waste and its energy conversions
CO4: Analyze the bio waste utilization to avoid the environmental pollution

UNIT-I:
Introduction to Energy from Waste: Classification of waste as fuel, Agro based, Forest residue, Industrial waste, MSW (Municipal solid waste) – Conversion devices – Incinerators, Gasifiers, Digestors

UNIT-II:
Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT-III:
Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNIT-IV:
Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNIT-V:
Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion.

UNIT-VI:
Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

TEXT BOOKS:
1. Biogas Technology-Transfer and Diffusion, M. M. EL-Halwagi, Elsevier Applied Science Publisher, New York, 1984
2. Introduction to Biomass Energy Conversions, Sergio Capareda

REFERENCES:

1. Non-Conventional Energy, Desai Ashok V., Wiley Eastern Ltd., 1990
2. Biogas Technology - A Practical Handbook, Vol. I & II, Khandelwal K. C. and Mahdi S. S., Tata McGraw-Hill Publishing Co. Ltd., 1983
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996

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M.Tech. III Semester (HWE)	**L**	**T/P**	**C**
	0	**16**	**8**

(18PW4HW03) PROJECT PART-I

M.Tech. IV Semester (HWE)	**L**	**T/P**	**C**
	0	**28**	**14**

(18PW4HW04) PROJECT PART-II

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Identify and formulate the problem (Industry/technical/societal)
CO-2: Analyze, design and develop a solution to industry/technical/societal problems
CO-3: Implement and execute the solution
CO-4: Demonstrate effective communication skills through oral presentation
CO-5: Engage in effective written communication through project report

COURSE OUTLINE:

- M.Tech. project work shall be for a minimum duration of 40 weeks spread over two semesters i.e., Project Part-I in III semester and Project Part-II in IV semester.
- A student shall be permitted to register for the major project after satisfying the attendance requirement in all the courses, i.e., theory and practical courses.
- Project reviews namely Project Review I and Project Review II in III semester and Project Review III and Project Pre-submission Seminar in IV semester shall be conducted during the course of Project work.
- A Project Review Committee (PRC) consisting of the Head of the Department as Chairperson and PG Coordinator, Project Supervisor and one senior faculty member of the Department offering the M. Tech. programme as members shall evaluate the progress of project work.
- In Project Review I, a student, in consultation with his Project Supervisor, shall present the title, objective and plan of action of his/her project work to the PRC for approval within four weeks from the commencement of III semester.
- A student can initiate the project work only after obtaining the approval of the PRC.
- The work on the project shall be initiated at the beginning of the III semester.
- Project Review II shall be conducted and evaluated at the end of the III semester.
- Project Review III shall be conducted during IV semester to examine the overall progress of the project work.
- A project pre-submission seminar shall be conducted to decide whether or not the project is eligible for final submission.
- After approval from the PRC, a soft copy of the thesis shall be submitted for PLAGIARISM check to the Examination Branch.
- At the end of IV semester upon fulfilling the above conditions, project viva-voce shall be conducted.
- A student shall submit project progress in prescribed report format during each of the project reviews.