M. TECH. DEGREE
TRANSPORTATION ENGINEERING AND MANAGEMENT

SYLLABUS
FOR
CREDIT BASED CURRICULUM
(With effect from 2016 - 2017)

DEPARTMENT OF CIVIL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
TIRUCHIRAPPALLI – 620015 INDIA

VISION AND MISSION OF THE INSTITUTE

Vision of the Institute

To provide valuable resources for industry and society through excellence in technical education and research.

Mission

To offer state-of-the-art undergraduate, postgraduate and doctoral programmes

To generate new knowledge by engaging in cutting-edge research

To undertake collaborative projects with academia and industries

To develop human intellectual capability to its fullest potential

VISION AND MISSION OF THE DEPARTMENT

Vision of the Department

Shaping infrastructure development with societal focus

Mission

Achieve International Recognition by:

- Developing Professional Civil Engineers

- Offering Continuing Education

- Interacting with Industry with emphasis on R&D

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates of the Programme will contribute to the development of transportation infrastructure that is sustainable.

2. Graduates of the Programme, as part of an organization or as Entrepreneurs, will continue to learn to harness evolving technologies.

3. Graduates of the Programme will be professional Transportation Engineers with ethical and societal responsibility.

PROGRAMME OUTCOMES (POs)

Post-Graduates of the Transportation Engineering and Management Programme will be able to:

a) Acquire in-depth knowledge of Transportation Engineering, including wider and global perspective, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.

b) Analyse complex Transportation Engineering problems critically, apply independent judgement for synthesising information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.

c) Think laterally and originally, conceptualise and solve Transportation Engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in Transportation Engineering.

d) Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyse and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually and in groups to the development of scientific and technological knowledge in Transportation Engineering.

e) Create, select, learn and apply appropriate techniques, resources, and modern engineering tools such as CAD, GIS and ITS including prediction and modeling to complex Transportation Engineering activities with an understanding of the limitations.

f) Possess knowledge and understanding of group dynamics, recognise opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

g) Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to efficiently manage Transportation Engineering projects and in multidisciplinary environments after consideration of economical and financial factors.

h) Communicate effectively and confidently on complex Transportation Engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.

i) Recognise the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

j) Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

k) Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn to improve without depending on external feedback.

M. Tech. (TRANSPORTATION ENGINEERING AND MANAGEMENT)

The total minimum credits required for completing the M. Tech. (Transportation Engineering and Management) Course is 66.

SEMESTER I

Code	Course of Study	C
MA601	Numerical Methods and Applied Statistics	3
CE601	Highway Traffic Analysis and Design	3
CE603	Pavement Materials and Design	4
	Elective – I	3
	Elective – II	3
	Elective – III	3
CE609	Traffic and Pavement Engineering Laboratory	2
		21

SEMESTER II

Code	Course of Study	C
CE602	Urban Transportation Systems	3
CE604	Transportation Planning	4
CE606	Pavement Construction and Management	3
	Elective – IV	3
	Elective – V	3
	Elective – VI	3
CE610	CAD in Transportation Engineering	2
		21

SUMMER TERM

	Practical Training (4 weeks)	-

SEMESTER III

Code	Course of Study	C
CE647	Project Work – Phase I	**12**

SEMESTER IV

Code	Course of Study	C
CE648	Project Work – Phase II	**12**

PROGRAMME ELECTIVES

Code	Course of Study	C
CE611	Traffic Flow Theory	3
CE612	Computational Techniques in Transportation Engineering	3
CE613	Transportation Network Analysis and Optimization	3
CE614	Transportation Systems Reliability and Safety	3
CE615	Transportation Economics	3
CE616	Waterway Transportation	3
CE617	Airport Planning and Design	3
CE618	Advanced Highway Materials	3
CE619	Intelligent Transportation Systems	3
CE620	Advanced Surveying and Cartography	3
CE621	Geospatial Techniques	3
CE622	Ground Improvement Techniques	3
CE623	Bridge Engineering	3
CE624	Urban Planning Techniques and Practice	3

ELECTIVES OFFERED FORM OTHER DEPARTMENTS

Code	Course of Study	C
MA608	Resource Management	3
HS601	Human Resource Management	3
HS602	Project Management	3
MB601	Systems Analysis	3

OPEN ELECTIVES

Code	Course of Study	C
CE619	Intelligent Transportation Systems	3
CE621	Geospatial Techniques	3
CE624	Urban Planning Techniques and Practice	3

Any other elective with the approval of the Chairman Board of Studies

SEMESTER I

MA601 NUMERICAL METHODS AND APPLIED STATISTICS

Course Objectives:

- To learn the different numerical techniques
- To be introduced to the fundamentals of probability
- To know the concepts of sampling and regression

Course Content:

Linear system – Gaussian elimination and Gauss – Jordan methods – matrix inversion – Gauss seidel method – Nonlinear equations – Regula falsi and Newton- Raphson methods – interpolation – Newton's and Lagrange's interpolation

Linear Programming – Graphical and Simplex methods – Big-M method - Two phase method - Dual simplex method - Dual theory – Sensitivity analysis – Integer programming – Transportation and Assignment problem.

Random variable – two dimensional random variables – standard probability distributions – Binomial Poisson and normal distributions - moment generating function

Sampling distributions – confidence interval estimation of population parameters – testing of hypotheses – Large sample tests for mean and proportion – t-test, F-test and Chi-square test – curve fitting-method of least squares

Regression and correlation – rank correlation – multiple and partial correlation – analysis of variance-one way and two way classifications – experimental design – Latin square design – Time series analysis.

References:

1. Bowker and Liberman, *Engineering Statistics*, Prentice-Hall, 1972.
2. Venkatraman, M.K., *Numerical Methods in Science and Engineering*, National Publisher Company.
3. M.K. Jain, S.R.K. Iyengar and R.K.Jain *Numerical Methods for scientific and engineering computation*, 5th edition, New Age International (p) Limited, 2007.
4. Hamdy A. Taha, *Operations Research: An introduction*, 8TH edition, Pearson Prentice Hall, 2007.
5. S. C. Gupta, *Fundamentals of Statistics*, Himalaya Publishing House, Seventh Revised Edition, 2009.
6. S.C. Gupta and V.K. Kapoor, *Fundamentals of Mathematical Statistics*, Sultan Chand and Sons, Eleventh Revised Edition.

Course Outcomes:

Upon completion of this course, the students should be able to:

- apply the different numerical techniques to transportation problems
- demonstrate applications of probability theory
- use regression and correlational analysis to process transportation data

CE601 HIGHWAY TRAFFIC ANALYSIS AND DESIGN

Course Objectives:

- To be aware of various methods of collecting traffic data
- To understand the basics of highway planning and design, and workout problems in design of road geometrics
- To learn the importance of road safety.

Course Content:

Elements of Traffic Engineering - road user, vehicle and road way and driver characteristics. - Design speed, volume. Passenger Car Units - Static and Dynamic- Highway capacity and level of service - capacity of urban and rural roads - Road user facilities - Parking facilities - Cycle tracks - Pedestrian facilities.

Traffic volume studies, origin destination studies, speed studies, travel time and delay studies, Parking studies, Accident studies.

Elements of design - Alignment - Cross sectional elements - Stopping and passing sight distance. Horizontal curves - Vertical curves. Design problems. Traffic regulation and control - Signs and markings - Traffic System Management.

Design of intersections – At-grade intersections- Principles of design – Channelization - Design of rotaries - Traffic signals - pre-timed and traffic actuated. Design of signal setting - phase diagrams, timing diagram – Signal co-ordination – Area traffic Control System. Grade separated interchanges - Geometric elements for divided and access controlled highways and expressways.

Traffic Safety – Principles and Practices – Safety along links - Safety at intersections. Road Safety Audit – Countermeasures, evaluation of effectiveness of counter-measures– Road safety programmes.

References:

1. ITE Hand Book, *Highway Engineering Hand Book*, Mc Graw - Hill.
2. AASHTO *A Policy on Geometric Design of Highway and Streets*
3. Pignataro, L.J., *Traffic Engineering – Theory & Practice*, John Wiley, 1985
4. R. J. Salter and N. B. Hounsel, *Highway Traffic Analysis and Desig*n, Macmillan Press Ltd, 1996.
5. Relevant IRC codes

Course Outcomes:

Upon completion of this course, the students should be able to:

- apply the concept of capacity
- conduct traffic surveys
- design the links and intersections
- build safety into every aspect of design

CE603 PAVEMENT MATERIALS AND DESIGN

Course Objectives:

- To learn the characteristics, properties and testing procedures of highway materials
- To study the behaviour of pavements under various loads
- To design the flexible and rigid pavements using different Empirical, semi-empirical and theoretical approaches

Course Content:

Types and component parts of pavements, Factors affecting design and performance of pavements. Highway and airfield pavements, Pavement Materials – Superpave - Bituminous mix design methods Bituminous Mixes: Mechanical properties - Resilient modulus, dynamic modulus and fatigue characteristics of bituminous mixes. Performance based Bitumen Specifications - Superpave mix design method

Stresses in Pavements: Flexible pavement - Layered system concepts, Stress solution for one, two and three layered systems, Fundamental design concepts. Rigid Pavements - Westergaard's theory and assumptions, Stresses due to curling, stresses and deflections due to loading, frictional stresses. Stresses in dowel bars and tie bars

Pavement Design Factors: Design wheel load, strength characteristics of pavement materials, climatic variations, traffic - load equivalence factors and equivalent wheel loads, aircraft loading, gear configuration and tyre pressure. Drainage – Estimation of flow, surface drainage, sub-surface drainage systems, design of sub-surface drainage structures

Flexible Pavement Design: Empirical, semi-empirical and theoretical approaches, design of highway and airport pavements by IRC, AASHTO Methods, Mechanistic –Empirical design, applications of pavement design software

Rigid Pavement Design: Types of joints and their functions, joint spacing; design of CC pavement for roads, highways and airports as per IRC, AASHTO, design of joints. Design of continuously reinforced concrete pavements. Reliability; Use of software for rigid pavement design

References:

1. Yoder and Witczak, *Priniciples of Pavement Design*, John Wiley and Sons
2. Yang. H. Huang, *Pavement Analysis and Design*, Second Edition, Prentice Hall Inc.
3. Rajib B. Mallick and Tahar El-Korchi, *Pavement Engineering – Principles and Practice*, CRC Press (Taylor and Francis Group)
4. W.Ronald Hudson, Ralph Haas and Zeniswki , *Modern Pavement Management*, Mc Graw Hill and Co
5. Relevant IRC Codes

Course Outcomes:

Upon completion of this course, the students should be able to:

- understand the properties and the various test for the highway materials and perform Bituminous Mix design
- analyze the stresses, strains and deflections in rigid and flexible pavements
- design both rigid and flexible pavements

CE609 TRAFFIC AND PAVEMENT ENGINEERING LABORATORY

Course Objectives:

- To organise traffic surveys and collect wide variety of traffic data, subjecting them to analysis and interpretation.
- To conduct various standard tests on soil, aggregate and bitumen.

Course Content:

Traffic Surveys: Volume count, Speed study, Parking study, Intersection turning movements, Speed and Delay study, Moving observer survey, Traffic noise measurement, Vehicle emission testing, Road lighting, User perception surveys, Origin Destination (O-D) Surveys, Roadside and Household interviews

Tests on sub grade soil, aggregates, bitumen, modified binders – as per BIS/ASTM

Soil stabilization – soil: lime stabilization. Soil: cement stabilization, mechanical stablization

Pavement evaluation, Structural and functional condition evaluation of pavements

Mix Design: Granular Sub-base, Bituminous Mixes – DBM, BC, SMA etc.,

Cement concrete Mixes - Mix design, NDT tests

Mini project report based on field and laboratory studies and data collected

References:

1. Khanna S. K., Justo C.E.G, & Veeraragavan A., *Highway Materials and Pavement Testing*, Nem Chand and Bros., Roorkee, 2013.
2. Kadyali, L.R., *Traffic Engineering and Transport Planning*, Khanna Publication, Delhi, 2011.

Course Outcomes:

Upon completion of this course, the students should be able to:

- conduct the traffic surveys, roadside and household interviews
- perform laboratory tests on subgrade soil, aggregates and bitumen
- carry out mix design for the CC pavement, GSB, DBM, SDBC, BC, etc.

SEMESTER II

CE602 URBAN TRANSPORTATION SYSTEMS

Course Objectives:

- To understand the characteristics of various urban transportation systems
- To learn the concepts of route network design and scheduling
- To study the planning aspects of terminals
- To be acquainted with sustainable urban transportation systems

Transport Systems: **U**rban modes and service types - Technological and operational Characteristics – environmental considerations – relative cost economics – criteria for selection

Route Network Design: Transportation Demand estimation, Data requirements, Network planning - Corridor identification - Route Systems and Capacity

Scheduling: Components –Scheduling procedure and patterns –Fleet Requirement – Bus and Crew scheduling - Rail operation design – Scheduling – Frequency and Headway

Terminal Planning: Planning and design of terminals - Bus stop capacity – Depot location - Depot layout, Parking patterns, Rail Transit: Station Arrangements - Way capacity and Station Capacity

Sustainable Urban Transportation: Preferential treatment for high occupancy modes, promoting non-motorized modes of transport - Integrated land use and transport planning – Demand management techniques - Integrated public transport planning; case studies- Smart Cities.

References:

1. Black, Alan, *Urban Mass Transportation Planning*, McGraw- Hill,Inc., New York,1995.
2. Vukan, R. Vuchic, *Urban Transit Systems and Technology*, John –Wiley & Sons, New Jersey, 2007.
3. Sigurd Grava, *Urban Transportation Systems – Choices for Communities*, The McGraw-Hill Companies, 2004
4. National Urban Transport Policy
5. Black, William R. Sustainable transportation: problems and solutions, The Guilford Press, 2010

Course Outcomes:

Upon completion of this course, the students should be able to:

- Compare and select suitable urban transportation systems
- Design route network and scheduling
- Apply the concepts of terminal planning
- Have a knowledge of sustainable transportation systems

CE604 TRANSPORTATION PLANNING

Course Objectives:

- To learn the fundamentals of transportation planning
- To understand the classical methods of urban transportation planning
- To be acquainted with the transportation landuse interaction

Course Content:

Urban morphology - Urbanization and travel demand – Urban activity systems and travel patterns – Systems approach – Trip based and Activity based approach - Urban Transportation Planning – Goals, Objectives and Constraints - Inventory, Model building, Forecasting and Evaluation - Study area delineation – Zoning - UTP survey

Trip generation models – Trip classification - productions and attractions – Trip rate analysis - Multiple regression models - Category analysis - Trip distribution models – Growth factor models, Gravity model and Opportunity modes.

Modal split models – Mode choice behavior – Trip end and trip interchange models - Probabilistic models - Utility functions - Logit models - Two stage model. Traffic assignment – Transportation networks – Minimum Path Algorithms - Assignment methods – All or Nothing assignment, Capacity restrained assignment and Multi path assignment - Route-choice behavior.

Landuse transportation models – Urban forms and structures - Location models - Accessibility – Landuse models - Lowry derivative models - Quick response techniques - Non-Transport solutions for transport problems.

Preparation of alternative plans - Evaluation techniques - Plan implementation - Monitoring - Financing of Project – urban development planning policy - Case studies.

References:

1. Hutchinson, B.G., *Principles of Urban Transport Systems Planning*, Scripta, McGraw-Hill, NewYork, 1974.
2. Khisty C.J., *Transportation Engineering - An Introduction*, Prentice Hall, NJ, 2007.
3. Papacostas C.S. and Prevedouros, P.D., *Transportation Engineering & Planning*, PHI, New Delhi, 2002.

Course Outcomes:

Upon completion of this course, the students should be able to:

- interpret the urban activity system and travel patterns
- demonstrate the classical methods of urban transportation planning
- apply four stage travel demand modeling

CE606 PAVEMENT CONSTRUCTION AND MANAGEMENT

Course Objectives:

- To learn the concept of pavement construction
- To evaluate the pavements based on the functional and structural characteristics
- To understand the concept of Pavement Management System, pavement failures and its evaluation

Course Content:

Flexible Pavement Construction: Earthwork, compaction and construction of embankments, specifications of materials, construction methods and field control checks for various types of flexible pavement materials in sub-base, base, binder and surface course layers and their choice.

Cement Concrete Pavement Layers: Specifications and method of cement concrete pavement construction; Construction of interlocking block pavements, Quality control tests; Construction of various types of joints.

Soil Stabilized Pavement Layers: Principles of gradation/proportioning of soil-aggregate mixes and compaction; Design factors, mix design, construction control and quality control checks for mechanical, soil-cement, soil-bitumen and soil-lime stabilisation methods. Use of additives, Numerical problems on mix design and applications.

Pavement Evaluation - Pavement Distress - Functional and structural condition of pavements, Pavement distress survey, Functional condition evaluation of pavements- Roughness, Skid Resistance. Structural evaluation of pavements - non destructive testing, Benkelman beam and Falling Weight Deflectometer, Pavement strengthening based on deflection as per IRC, Maintenance and rehabilitation techniques.

Pavement Management Systems - Pavement Management Systems- Components, structure, data requirements, Project level and Network level needs, Pavement performance prediction – concepts, modelling techniques– AASTHO, CRRI and HDM models, Budget forecasting for maintenance and rehabilitation, Ranking and optimization methodologies, life cycle costing,

References:

1. Prithvi Singh Kandhal, *Bituminous Road Construction in India*, PHI Learning Pvt. Ltd., Delhi, 2016.
2. P. Purushothama Raj, *Ground Improvement Techniques*, Laxmi Publications (P) Ltd., New Delhi, 2005.
3. Transport and Road Research Laboratory, *Soil Mechanics for Road Engineers*, HMSO, London, 1974.
4. W.Ronald Hudson, Ralph Haas and Zeniswki, *Modern Pavement Management*, Mc Graw Hill and Co
5. MoRTH, *Specifications for Road and Bridge Works*, Fifth Revision, IRC, New Delhi, 2013.
6. Relevant IRC codes and Ministry Specifications.

Course Outcomes:

Upon completion of this course, the student will be able to:

- carry out the construction of flexible and rigid pavements
- understand the structural and functions failure and the evaluation of pavements
- do develop pavement management systems

CE610 CAD IN TRANSPORTATION ENGINEERING

Course Objectives:

- To be acquainted with transportation software, and the latest developments such as GIS and Remote sensing
- To be introduced to various software packages on Windows.
- To learn the fundamentals of CAD and DBMS.

Course Content:

Traffic related Software – VISSIM, VISWALK, TRANSYT, Mx Road
Transportation Planning Software – NLOGIT, CUBE, CUBE VOYAGER
Pavement Engineering Software – KENPAVE, IITPAVE, HDM4, GAMS
GIS and Remote Sensing Packages – ArcGIS, ERDAS Imagine,

Spreadsheet concepts – Worksheet calculations in Civil Engg. - Regression & Matrix Inversion, Transportation Planning
Development of C programs to solve problems using numerical techniques

References:

1. Rajaraman, V., *Computer Oriented Numerical Methods*, Prentice – Hall of India, 1995
2. Chapra S.C., and Canale R.P., *Numerical Methods for Engineers*, McGraw – Hill, 2004
3. Software Manuals

Course Outcomes:

Upon completion of this course, the students should be able to:

- employ various transportation software
- operate various GIS and Remote Sensing packages
- develop C programs for various numerical techniques

ELECTIVES

CE611 TRAFFIC FLOW THEORY

Course Objectives:

- To be introduced to traffic flow theory.
- To study macroscopic and microscopic modeling.
- To learn the fundamentals of ITS.

Course Content:

Traffic stream parameters - Fundamental diagram of volume-speed-density surface. Discrete and continuous probability distributions. Merging manoeuvres - critical gaps and their distribution.

Macroscopic models - Heat flow and fluid flow analogies - Shock waves and bottleneck control approach.

Microscopic models - Application of queuing theory - regular, random and Erlang arrival and service time distributions - Queue discipline - Waiting time in single channel queues and extension to multiple channels.

Linear and non-linear car following models - Determination of car following variables - Acceleration noise.

Geographical Information System – Global Positioning System – Intelligent Transportation Systems - Area Traffic Control – Automatic Toll Collection – Smart Cards – Collision Detection System.

References:

1. Drew, D.R., *Traffic Flow Theory and Control*, McGraw Hill., 1978.
2. TRB, *Traffic Flow Theory* - A Monograph, SR165, 1975.
3. Burrough P.A. and Rachel A. McDonell, *Principles of Geographical Information Systems*, Oxford Publication, 2004.
4. Sussman, J. M., *Perspective on ITS*, Artech House Publishers, 2005.

Course Outcomes:
Upon completion of this course, the student will be able to:

- analyze the traffic stream parameters.
- apply the queuing theory
- define the significance of ITS under Indian conditions.

CE612 COMPUTATIONAL TECHNIQUES IN TRANSPORTATION ENGINEERING

Course Objectives:

- To be introduced to systems approach.
- To learn the fundamentals of simulation and the GPSS language.
- To be introduced to advanced computational techniques such as GA and ANN.

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

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

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

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

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

References:

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

Course Outcomes:
Upon completion of this course, the students should have:

- a working knowledge of simulation and GPSS programming.
- a good understanding of GA applications
- the ability to apply ANN

CE613 TRANSPORTATION NETWORK ANALYSIS AND OPTIMIZATION

Course Objectives:

- To learn the fundamental definitions of networks.
- To study the different Shortest Path Algorithms and network assignment techniques.
- To be exposed to various network analysis software.

Course Content:

Network flows: Applications, definitions, graphs, paths, trees, cycles, loops, walk, network representation (adjacency list and matrices) and basic network transformations; Network algorithms; Complexity, Search Algorithms, Strategies for designing polynomial algorithms.

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.

Minimum cost network assignment: optimality conditions, cycle-canceling algorithm, Successive shortest path algorithm, other polynomial time variants; Network equilibrium analysis; principles and optimisation formulations, Frank-Wolfe algorithm; Special cases and variants.

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.

Computer Software: Principles of TRIPS, SATURN, EMME/2, CUBE; Demo Versions, Case studies

References:

1. Ahuja, R.., Magnanti, T.L., and Orlin, J.B., *Network Flows: Theory, Algorithms and Application*, Prentice Hall, New Jersey, 1993.
2. Bell, M.G., *Transportation Networks*, Elsevier Science Publishers, 1999.

Course Outcomes:

Upon completion of this course, the student will be able to:

- define and analyze different types of networks.
- apply the Shortest Path and Minimum cost algorithms
- have a working knowledge of various network analysis software.

CE614 TRANSPORTATION SYSTEMS RELIABILITY AND SAFETY

Course Objectives:

- To learn the planning, operation and maintenance of different modes of transport and their integration, interaction and impact on environment.
- To be aware of the development of transport, various road development plans and policies in India.

- To study the terminal operational controls of urban transportation systems.

Course Content:

Transportation and Society- Role of Transport in Society and Economy - Functions and Problems in Transportation Planning - Economic, Geographical, Political, Technological, Social and Cultural Factors in Planning of Transportation System. Transport Technology: System Classification and their Variation; Conventional Systems and Unconventional Systems - Air, Water and Ground Modes

Modes of Transport and their Characteristics, Propulsion Forces - Factors in Operation - Levels of Service and Performance Criteria - Quality of Service: Capacity and Levels of Service of different Transportation Systems; mobility and accessibility – Flexibility - Speed, Acceleration, Deceleration - Comfort and Environmental Effects - Time Spent and Cost – Integration of modes.

A Brief Historical Development of Transportation Systems in India: Growth of Transport - Road Development Plans - Imbalances in Transport System - National Transport Policy Recommendations - Optimum Inter Model Mix-Study - Vision 2021, NHDP, PMGSY, Rural Roads Vision 2025 - IRC, CRRI etc. - Inland waterways in India

Planning of passenger and goods terminal facilities of Air, Water, Railway and Highway Transportation Systems – requirements and typical layouts - passenger facilities - parking configuration - terminal requirements – goods facilities and containerization

Operational Controls of Air, Water, Railway and Highway Transportation Systems: Functions of Control & Communications - Signals and Traffic Control Devices - Navigational Aids of the different Transportation Systems. Air Traffic Control; Navigational Control. Automatic Signaling Systems of Railway and Highway Movements.

References:

1. Paquette, R.J., et al, *Transportation Engineering Planning and Design*, John Wiley & Sons, New York, 1982.
2. Horenjeff Robert; *The planning & Design of Airports*, McGraw Hill Book Co., 2007
3. Alan Black, *Urban Mass Transportation Planning*, McGraw-Hill, 1995.

Course Outcomes:

Upon completion of this course, the student will be able to:

- understand different transport plans and policies
- characterize different modes of transport and their impact
- controls and terminal facilities of transportation system

CE615 TRANSPORTATION ECONOMICS

Course Objectives:

- To be aware of the concepts in transportation decision making.
- To learn about transportation cost.
- To understand economic analysis of transport projects.

Course Content:
Introductory Concepts in Transportation Decision Making: Overall transportation project development, budgeting, financial planning, the process of transportation project development, models associated with transportation impact evaluation.

Transportation costs - Classification of transportation costs, transportation agency costs, transportation user costs, general structure and behavior of cost functions and road pricing. Estimating Transportation Demand and Supply - supply equilibration, dynamics of transportation demand and supply, elasticity of travel demand and supply, classification of elasticity.

Vehicle operating costs: Fuel costs - Maintenance and spares, Depreciation - Crew costs - Value of travel time savings - Accident costs. Economics of traffic congestion - Pricing policy.

Economic analysis of projects - Methods of evaluation - Cost-benefit ratio, first year rate of return, net present value, and internal-rate of return methods; Indirect costs and benefits of transport projects.

Financing of road projects - methods – Private Public Partnership (PPP) - Toll collection - Economic viability of Design-Build-Operate-Transfer Schemes – Risk Analysis – Value for Money analysis - Case Studies.

References:
1. Winfrey, *Economic analysis for Highways,* International Textbook Company, Pennsylvania, 1969.
2. CRRI, *Road User Cost Study in India*, New Delhi, 1982
3. IRC, *Manual on Economic Evaluation of Highway Projects in India*, SP30, 2007

Course Outcomes:
Upon completion of this course, the students should be able to:
- understand the decision making and financing in transportation projects
- calculate transportation demand, vehicle operation cost and accident cost.
- formulate the economic evaluation of transportation projects including the Private Public Partnership

CE616 WATERWAY TRANSPORTATION

Course Objectives:
- To know about water transport and harbour planning
- To learn about different docks and repair systems
- To understand the navigational aids, coastal protection and ports

Course Content:

Harbour Planning: Types of water transportation, water transportation in India, requirements of ports and harbours, classification of harbours, selection of site and planning of harbours, location of harbour, traffic estimation, master plan, ship characteristics, harbour design, turning basin, harbour entrances, type of docks, its location and number, Site

investigations – hydrographic survey, topographic survey, soil investigations, current observations, tidal observations.

Docks and Repair Facilities: Design and construction of breakwaters, berthing structures - jetties, fenders, piers, wharves, dolphins, trestle, moles, Harbour docks, use of wet docks, design of wet docks, repair docks, lift docks, dry docks, keel and bilge blocking, construction of dry docks, gates for dry docks, pumping plant, floating docks, slipways, locks, size of lock, lock gates, types of gates.

Navigational Aids: Requirements of signals, fixed navigation structures, necessity of navigational aids, light houses, beacon lights, floating navigational aids, light ships, buoys, radar.

Dredging and Coastal Protection: Classification, types of dredgers, choice of dredger, uses of dredged materials, coastal erosion and protection, sea wall, revetment, bulkhead, coastal zone and beach profile.

Port facilities: Port development, port planning, port building facilities, transit sheds, warehouses, cargo handling facilities, container handling terminal facilities, shipping terminals, inland port facilities. Inland waterways, Inland water transportation in India, classification of waterways, economics of inland waterways transportation, national waterways

References:

1. Bindra, S.P. *A Course in Docks and Harbour Engineering*, Dhanpat Rai & Sons, New Delhi, India, 1992.
2. Seetharaman, S. *Dock and Harbour Engineering*, Umesh Publications, New Delhi, India, 1999.
3. Srinivasan, R., Harbour, Dock and Tunnel Engineering, Charotar Publishing House, Anand, India, 2009.

Course Outcomes:

Upon completion of this course, the students should be able to:

- understand the aspects of harbour design
- design and construction of breakwater and docks
- plan port and other facilities in the port

CE617 AIRPORT PLANNING AND DESIGN

Course Objectives:

- To be aware of aircraft characteristics and airport planning
- To understand the geometrics of airport infrastructure and terminal area planning
- To learn the importance of air traffic management

Aircraft Characteristics: Aircraft characteristics related to airport design - Landing gear configurations, aircraft weight, engine types. Atmospheric conditions affecting aircraft performance: air pressure, temperature, wind speed and direction. Aircraft performance characteristics: speed, payload and range, runway performance, declared distances, wingtip vortices.

Airport planning and air travel demand forecasting: Airport system planning - Hierarchy of Planning - Airport Master Plan - Elements of Airport Master Plan - Airport Layout Plan - Forecasting methods: time series method, market share method, econometric modelling. Facilities requirements – Design alternatives - Financial plans- Land use planning – Environmental planning - Air Transport Planning in India – Airport Site Selection -

Geometric Design of the Airfield: Airport classification - Principles of Airport Layout - Airfield Configuration - Runway Orientation - Obstructions to Airspace - Runway Length - Runway and Taxiway Cross Section - Longitudinal-Grade Design for Runways and Stop-ways - Longitudinal-Grade Design for Taxiways -Taxiway Design - exit taxiway - Capacity - Level of Service - Airside Capacity - Factors Affecting Airside Capacity and Delay - Determination of Runway Capacity and Delay - Annual Service Volume - Calculating Aircraft Delay - Taxiway and Gate Capacity - Holding Aprons - Terminal Aprons – Airport drainage - Estimation of Runoff - Collection and Disposal of Runoff - Subsurface Drainage

Planning and Design of the Terminal Area: Components of airport terminal - Function of Airport Passenger and Cargo Terminal - Facilities Required at Passenger Terminal - Design considerations: terminal demand parameters, facility classification, level of service criteria. Terminal planning process: overall space requirements, concept development, horizontal distribution concepts, vertical distribution concepts. Passenger and Baggage Flow - Apron gate system: number of gates, ramp charts, gate size, aircraft parking type, apron layout, apron circulation, passenger conveyance to aircraft, apron utility requirements Design of Air Freight Terminals - Airport access - Airport Landside planning - Capacity

Air Traffic Management: Navigational aids: ground based systems, satellite based systems – Air traffic control and surveillance facilities – Weather reporting facilities - Requirements of visual aids, Air field lighting - approach lighting system configurations, visual approach slope aids, threshold lighting - Runway lighting, taxiway lighting. Runway and taxiway marking, airfield signage - Air traffic separation rules: vertical separation, flight altitudes, longitudinal separation, and lateral separation – future enhancements to air traffic management.

References:

1. Geoffrey D. Gosling; Airport ground access mode choice models, Transportation Research Board, Washington, D.C., 2008
2. Norman J. Ashford, Saleh Mumayiz, Paul H. Wright; Airport Engineering Planning, Design, and Development of 21st century Airports, John Wiley & Sons, Inc.,2011
3. Horonjeff, R., McKelvey, F. X., Sproule, W. J., and Young, S. B. Planning and Design of Airports, Fifth Edition, McGraw-Hill, New York, USA, 2010.
4. Young, S. B., and Wells, A. T. Airport Planning and Management, Sixth Edition, McGraw-Hill, New York, USA, 2011.
5. Khanna, S. K., Arora, M. G., and Jain, S. S. Airport planning and Design, Sixth Edition, Nem Chand and Bros, Roorkee, India, 2012.

Course Outcomes:

Upon completion of this course, the students should be able to:

- apply the concept of airport planning
- design the runways, taxiways and airport terminal facilities
- plan air traffic management

CE618 ADVANCED HIGHWAY MATERIALS

Course Objectives:

- To study the properties and test on aggregate, bituminous materials, composites and recycled waste products
- To be introduced to the principles of bituminous pavement construction
- To learn the procedure for bituminous and PCC mix design

Course Content:

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.

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.

Cement /concrete based materials: Cement – properties – PCC mix design and properties – modified PCC – Mix Design – Behaviour – Performance – Tests on Cement and Concrete mixes. High Performance Concrete – low shrinkage – increased strength.

Composites, Plastics and Geosynthetics: Plastics and polymerization process – properties – durability and chemical composition – Reinforced Polymer Composites – Geosynthetics – Dry Powdered Polymers – Enzymes.

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.

References:

1. P. T. Sherwood, *Alternative Materials in Road Construction*, Thomas Telford Publication, London, 1997.
2. RRL, DSIR, *Soil Mechanics for Road Engineers*, HMSO, London , 1995
3. Koerner, R. M. *Designing with Geosynthetics*, Prentice Hall, Englewood Cliffs, New Jersey, U.S.A.
4. Shan Somayaji, *Civil Engineering Materials*, second edition, Prentice Hall Inc., 2001.

Course Outcomes:

Upon completion of this course, the students should be able to:

- understand the properties and test procedures of aggregate, bituminous materials, composites and recycled waste products
- know the different types of bituminous pavement construction and its principles
- do bituminous and PCC mix design

CE619 INTELLIGENT TRANSPORTATION SYSTEMS

Course Objectives:

- To learn the fundamentals of ITS.
- To study the ITS functional areas
- To have an overview of ITS implementation in developing countries

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

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

ITS functional areas – Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Commercial Vehicle Operations (CVO), Advanced Vehicle Control Systems (AVCS), Advanced Public Transportation Systems (APTS), Advanced Rural Transportation Systems (ARTS).

ITS User Needs and Services – Travel and Traffic management, Public Transportation Management, Electronic Payment, Commercial Vehicle Operations, Emergency Management, Advanced Vehicle safety systems, Information Management.

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

References:
1. ITS Hand Book 2000: *Recommendations for World Road Association (PIARC)* by Kan Paul Chen, John Miles.
2. Sussman, J. M., *Perspective on ITS*, Artech House Publishers, 2005.
3. National ITS Architecture Documentation, US Department of Transportation, 2007 (CD-ROM).

Course Outcomes:
Upon completion of this course, the students should be able to:
- understand the sensor and communication technologies.
- apply the various ITS methodologies
- define the significance of ITS under Indian conditions

CE620 ADVANCED SURVEYING AND CARTOGRAPHY

Course Objectives:
- To understand the basics of advanced surveying and cartography
- To understand in detail the different types of maps, coordinate systems and coordinate transformation
- To be introduced to working principles of topographical survey, geodesy and basis of GPS.

Course Content:
Advanced Surveying – Concepts and Principle of working - comparison with conventional surveying – Electro magnetic distance measurement (EDM) – Working principle - classification - electromagnetic distance measuring system – Total Station – Digital Level - application of Lasers in measurement

Cartography – Definition – Maps – Map Scale – Map Type - co-ordinate system - Thematic maps - map projections - classification - properties, uses and choice of projections - UTM system - projection used in SOI topographical sheets, map reproduction – Coordinate Transformation

Topographical Surveying - Introduction to topographical mapping, scale of topographical maps, Indian topographical series and their numbering system - topographical survey methods – Triangulation and precise leveling – Photogrammetry – Parameter Measurement using Photos

Geodesy – Figure of earth – Classification – Datums – Reference frames – Coordinate systems – computation of spherical coordinates – Space Geodesy – VLBI, SLR.

GPS Basics – system overview – working principle of GPS – Satellite ranging –calculating position – Ranging errors and its correction – GPS surveying Methods – RTK - DGPS – GNSS.

References:
1. Hoffman.B, H.Lichtenegga and J.Collins. Global Positioning System - Theory and Practice, Springer - Verlag Publishers, 2001
2. Borden D. Dent, Jeffrey Troguson, Thomas W. Hodler. Cartography: Thematic map Design, McGraw-Hill Higher Education, 2008.
3. Wolfgang Torge. Geodesy, Berlin: de Gruyter, 2001
4. Satheesh Gopi. Advanced Surveying, Pearson Education, 2007.

Course Outcomes:
Upon completion of this course, the student will be able to:
- describe the methods and applications of advanced surveying in the field of transportation engineering.
- define the correct coordinate system and methods of transformation.
- define the significance of topographical survey, geodesy and GPS in transportation engineering.

CE621 GEOSPATIAL TECHNIQUES

Course Objectives:
- To understand the basics of advanced tools such as Remote sensing, GIS and GPS
- To highlight their applications in the field of Civil engineering
- To be introduced to various Remote Sensing/GIS/GPS equipment & processing packages.

Course Contents:
Concepts and foundations of remote sensing – energy source EMS – Remote Sensing System – EMR interaction with particulate matter – Spectral Signature curves – Data Acquisition and interpretation – Visual Image Interpretation

Platform/Sensors – Classification – satellite system/sensor parameters – earth resources and meteorological satellites – Data Processing – Digital Image processing – Image Classification – Data Extraction - ground truthing.

GIS - History of Development – Components/Architecture – Spatial and Non–Spatial Data – Raster and Vector data structures – Data Input Sources – DBMS – Data handling in GIS – Data Extraction – Representation of Spatial and Attribute Data – Georeferencing – Digitization

Raster and Vector spatial analysis – Spatial and Mathematical operations in GIS – Overlay – Query – Buffers – Spatial Analysis – Density Analysis – Spatial Autocorrelation - network analysis – nearest neightbour analysis – DEM - Data quality – Sources/ types of errors

Application of Remote Sensing, GIS and GPS in Transportation Engineering – Transportation Data Capture – Shortest Path Analysis – Facility Location within Networks – Urban Sprawl – Advanced Transportation Analysis – Travel Demand Analysis – Landuse Transportation Modelling - Route Planning – ITS Applications

References:

1. Burrough P.A. and Rachel A. McDonell, *Principles of Geographical Information Systems*, Oxford Publication, 2004.
2. C.P. Lo and Albert K. W. Yeung, *Concepts and Techniques of Geographical Information Systems*, Prentice–Hall India, 2006.
3. Thomas. M. Lillesand and Ralph. W. Kiefer, *Remote Sensing and Image Interpretation*, John Wiley and Sons, 2003.
4. Joseph G., *Fundamentals of Remote Sensing*, University Press, 2005.
5. Panigrahi, N., *Geographical Information systems*, University Press, 2005.

Course Outcomes:

Upon completion of this course, the student will be able to:

- describe the methods and applications of remote sensing in Civil engineering.
- define and summarize surveying techniques using global positioning systems
- define the significance of GIS in civil engineering.

CE622 GROUND IMPROVEMENT TECHNIQUES

Course Objectives:

- To learn how to improve weak soils by modern ground improvement techniques
- To study the role of soil reinforcement in soil stabilization
- To know the importance of geo-synthetics in ground improvement

Course Content:

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

Soil Stabilization: Science of soil stabilization – Mechanical modification – Hydraulic modification – Dewatering systems – Chemical modification – Modification by admixtures like lime, Cement, Bitumen etc. – Grouting – Deep jet mixing methods

Recent Ground improvement techniques: stabilization using industrial waste – modification by inclusion and confinement – soil nailing – stone column – compaction piles – dynamic compaction – prefabricated vertical drains – preloading – electro – osmosis – soil freezing vacuum consolidation – deep explosion – dry powdered polymers - enzymes

Soil reinforcement: Historical background, RCC – Vidalean concept of reinforced earth – Mechanisms – Types of reinforcements – Soil – Reinforcement – Interaction studies – Internal & External stability criteria – Design Principles of steep reinforced soil slops – pavements – Embankments on soft soils.

Geo-Synthetics: Geo-synthetic clay liner – Construction details – Geo Synthetic Materials – Functions – Property characterization – Testing Methods for Geo – Synthetics – Recent research and Developments. Control of Improvement – Field Instrumentation – design and analysis for bearing capacity and settlement of improved deposits.

References:

1. Hausmann, M.R., *Engineering Principles of Ground Modification*, McGraw – Hill International Editions, 1990.
2. Purushotham Raj, *Ground Improvement Techniques*, Laxmi Publications, New Delhi
3. Sharma.S.K., Priniciples, *Practice and Design of Highway Engineering*, S.Chand & Co. New Delhi,1985.
4. Jones C. J. F. P, *Earth Reinforcement and Soil Structures*, Butterworths, London.

Course Outcomes:

Upon completion of this course, the students should be able to:

- understand the importance of ground improvement techniques in civil engineering construction activities.
- do reinforced wall design using steel strip or geo-reinforcement
- perform any modern ground improvement design including soil stabilization

CE623 BRIDGE ENGINEERING

Course Objectives:

- To develop an understanding of basic concepts in bridge engineering like components, classification, importance, investigation of bridges and loading conditions.
- To study the design of Culvert, Foot Bridge, Slab Bridge, T-beam Bridge and Box Culvert using IRC.
- To study the design of various sub-structures like piers, abutments, foundations and study the importance of the bearing and joints in construction of the bridge.

Course Content:

Components of Bridges – Classification – Importance of Bridges – Investigation for Bridges – Selection of Bridge site – Economical span – Location of piers and abutments – Subsoil exploration – Scour depth – Traffic projection – Choice of bridge type

Specification of road bridges – width of carriageway – loads to be considered – dead load – IRC standard live load – Impact effect

General design considerations – Design of culvert – Foot Bridge - Slab Bridge – T-beam bridge – Pre-stressed concrete bridge – Box Culvert - Fly over bridges

Evaluation of sub structures – Pier and abutments caps – Design of pier – Abutments – Type of foundations

Importance of Bearings – Bearings for slab bridges – Bearings for girder bridges – Electrometric bearing – Joints – Expansion joints. Construction and Maintenance of bridges – Lessons from bridge failures

References:

1. Ponnuswamy, s., *Bridge Engineering*, Tata McGraw - Hill, New Delhi, 1997
2. Victor, D.J., *Essentials of Bridge Engineering*, Oxford & IBH Publishers Co., New Delhi, 1980.
3. N. Rajagopalan, *Bridge Superstructure*, Narosa Publishing House, New Delhi, 2006.

Course Outcomes:

Upon completion of this course, the student will be able to:

- prepare a detailed project report for the construction of bridge giving hydraulic particulars of the river and soil details and be able to select the suitable site and type of the bridge.
- design various types of bridges like Culvert, Slab Bridge and T-beam Bridge using provisions of IRC.
- design pier, abutment, foundations, bearing and detailing of joints.

CE624 URBAN PLANNING TECHNIQUES AND PRACTICE

Course Objectives:

- To understand the different types of plans
- To know the different analytical techniques of plan
- To expose to different experience of planning of new towns

Course Content:

Planning System: Planning system in India, Introduction to Master Plan, Structure Plan, and Detailed Development Plans. Concepts of Smart city.

Planning Surveys : Type of planning surveys, data identification for various plan preparation. Aerial photo and remote sensing techniques in planning. Formulation of standards for various urban functions.

Analytical Techniques: Delphi, Trade off-game, simulation models, gravity analysis, Lowry model, Threshold analysis, Multivariate analysis. Techniques of delineation of planning areas and planning regions. Land use models.

Urban Renewal: Urban Decay: Causes and Impacts, Urban Renewal: significance, scope and limitations, identification of renewal areas, Renewal strategies. National Urban Renewal Schemes and policies.

New Towns and Global Trends: Role and Functions, Planning and development considerations, Asian and Indian experience of planning and development of new towns. Recent trends in international planning.

References:

1. Lichfield N., et.al. (eds), 1998, Evaluation in Planning: Facing the challenge of complexity, Kluwer Academic publications, Dordrecht.
2. Knox P, and P. Taylor (eds), 1995, World Cities in a World System, Cambridge University Press, Cambridge.
3. Kaiser Edward J., et.al., 1995, Urban Landuse Planning 4th (ed) Urbana, University of Illinois Press
4. Paul R. Wolf, 1986, Elements of Photogrammetry, McGraw Hill Books Co., London.
5. Hall, P., 2001, Cities of tomorrow: an intellectual history of urban planning and design in the twentieth century, Blackwell, London.
6. Peter, G.H. and Tewdwr-Jones, M., 2011 Urban and Regional Planning, Routledge, London. Fifth Edition.

Course Outcomes:

Upon completion of this course, the student will be able to:

- plan for smart city
- use different planning surveys
- renew the urban areas and plan new towns

MA608 RESOURCE MANAGEMENT

Course Objectives:

- To understand the theory of optimization methods and algorithms developed for solving various types of optimization problems.
- To introduce fundamentals of non-linear optimization theory and methods.
- To introduce problems such as shortest paths within the minimum cost flow framework.

Course Content:

Non-Linear Programming Problems: One variable unconstrained optimization, multivariable unconstrained optimisation, Karush-Kuhn-Tucker (KKT) conditions for constrained optimization, quadratic programming, separable programming, convex and non convex programming, steepest and Quasi-Newton method.

Dynamic Programming: Characteristics of dynamic problems, deterministic dynamic programming and probabilistic dynamic programming

Network Analysis: Shortest path problems, minimum spanning tree problem, maximum flow problem, minimum cost flow problem, network simplex, interior point methods.

Stochastic programming, Nonlinear goal programming applications, Geometric Programming.

Multi-objective Optimization Problems: Linear and non linear programming problems, Weighting and Epsilon method, P-norm methods, Gradient Projection Method, STEM method, Convex Optimization.

Reference Books:

1. Ehrgott M. *Multi-criteria Optimization*, Springer
2. Colletee Y. and Siarry P. *Multiobjective Optimization*,Springer
3. Miettien K.M. *Non-linear multi-objective optimization*, Kluwers International Series
4. Rao S. S.*Engineering Optimization Theory and Practices*, John Wiley and Sons
5. Deb K. *Multi-objective evolutionary optimization for product design and manufacturing*, Springer

Course Outcomes:

Upon completion of this course, the student will be able to:

- formulate optimization problems
- apply basic concepts of mathematics to formulate an optimization problem
- apply basic knowledge of optimization to formulate and solve engineering problems.

HS601 HUMAN RESOURCE MANAGEMENT

Course Objectives:

- To learn the basic concepts and frameworks of human resource management.
- To define the process of job analysis and discuss its importance as a foundation for human resource management practice.
- To look into numerous problems of HRM and their causes and the action plans to be implemented to save these problems.

Course Content:

Human Resource Management- Definition – Features- Importance- Objective of Human Resource Management- Concepts – Commodity, Production, Goodwill, Humanitarian, Human Relation Concepts- Approaches to the study of Human Resource Management- systems, Situational, Role, Process approaches- Human Resources Accounting-Case studies.

Job Design- Approach to Job Design- Engineering, Human, The Job characteristics, Approaches-Job Design Process- Job Design Methods; Job Rotation, Job Enlargement- Job Enrichment- Job Evaluation- Methods of Job Evaluation- Performance Appraisal Methods- Case Studies.

Human Resource Planning- Benefits –Problems-Retention Plan- Organizing Human Resource Planning- Recruitment policy- Sources of Recruitment- Selection- Meaning- Definition- Need for scientific Selection System- Selection Process- Types of psychological Tests- Placement- Induction- Employee Training- objectives, Training Process- Methods of Training- Case Studies.

Contemporary Problems of HRM- Quality of Work life- Specific Issues in Quality Work Life (QWL) - QWL and Productivity- Barriers to Quality of Work Life- Strategies for Improvement in QWL- Quality circles- Definition- Objectives- Processes- Techniques- Organization Structure- Workers participation in Management- Methods of Worker's participation in Management- Morale and Productivity- Case Studies.

Industrial Relations- Concepts, Structures and Functions– Trade Unions- Unionization- Law and Environment- Collective Bargaining- Concept- Process- Trends and Conclusions- Employee Grievances- Approaches- Procedures- Industrial Conflicts- Nature of Conflict- Statutory, Non- Statutory and other Statutory measures- Case studies.

References:

1. Rao V. S. P, Rao Subbha P, *Personnel/ Human Resource Management- Texts*, Cases and Games- Konark Publishers Pvt. Ltd, 2008.

2. Decenzo A. David, Robbins P.Stephen, *Personnel/ Human Resource Management*-PHI-2012.

3. Monappa Arun, Nambudiri Ranjeet, Patturaja Selvaraj, *Industrial Relations and Labour laws*, TMH- 2012.

4. Srivastava S. C., *Industrial Relations and Labour Laws*, Vikash Publishing House Pvt. Ltd. -2012.

5. Pareek Udai, Rao T. V., *Designing and managing Human Resource Systems*, Oxford and IBH- 2005.

Course Outcomes:

Upon completion of this course, the student will be able to:

- discuss how to strategically plan for the human resource needed to meet organizational goals and objectives.
- provide innovative solutions to problems in the fields of HRM.
- compare the common methods for recruiting and selecting human resources.

HS602 PROJECT MANAGEMENT

Course Objectives:

- To introduce the key components and techniques of project management.
- To understand the concepts of project definition, life cycle and systems approach.
- To handle the tasks of time estimation and project scheduling including PERT and CPM.

Course Content:

Basics of Project Management and Organizational Issues: Introduction, Need and principles of Project Management, The Project Life Cycle, The Project Manager (PM), Phases of Project Management Life Cycle, Project Management Processes, Impact of Delays in Project Completions, Relationship between Project Manager and Line Manager, Conflict Resolution, Team Management and Diversity Management, Change management.

Project Identification, Selection and Planning: Project Identification Process, Project Initiation, Pre-Feasibility Study, Feasibility Studies, Project Break-even point Project Planning Process, `and Work Breakdown Structure (WBS)

PERT, CPM and Resources: Determination of the Critical Path, PERT Model, Measures of variability, CPM Model, Network Cost System

Project Risk Management, Quality, and Evaluation: Steps in Risk Management, Risk Identification, Risk Analysis, Reducing Risks, Quality Concepts, Value Engineering, Project

Performance Evaluation, Benefits and Challenges of Performance Measurement and Evaluation, Controlling the Projects

Project Termination, Follow-up, Software: Project Close-out, Steps for Closing the Project, Project Termination, and Project Follow-up, Advantages of using Project Management Software, Software Illustration, and Case Studies in Project Management

References:

1. Harold R. Kerznet. Project Management : A system approach to Planning, Scheduling, and Controlling. 11th Edition.
2. A Guide to the Project Management body of knowledge. PMBOK(R) Guide 5th Edition.
3. Ramakrishna, Kamaraju. Essentials of Project Management, PHI, 2010.
4. Harold R. Kerznet. Project Management Metrics, KPIs, and Dashboards: A Guide to measuring and Monitoring Project Performance . 2nd Edition. Wiley, 2013.
5. Harold R.Kerzet. Project Management: Case Studies 4th Edition. Wiley, 2014.

Course Outcomes:

Upon completion of this course, the students should be able to:

- gain concepts to address specific management needs at the individual, team, division and /or organizational level.
- conduct project planning activities that accurately forecast project costs, timelines and quality.
- understand and use risk management analysis techniques that identify the factors that put a project at risk.

MB601 SYSTEM ANALYSIS

Course Objectives:

- To introduce students to fundamental concepts involved in using sample data to make inferences about populations.
- To know the basics and consecutive model studies in a database.
- To understand the theory and application of generalized linear models and related statistical topics.

Course Content:

Descriptive statistics, interval estimation, hypothesis testing, and population comparisons. Introduction to multivariate statistics- Degree of Relationship among Variables-Review of Univariate and Bivariate Statistics-Screening Data Prior to Analysis-Missing Data, Outliers, Normality, Linearity, and Homoscedasticity.

Linear regression –Single and two variables, Assumptions, Regression fundamentals, Manipulating variables in regression, Stepwise, Forward, backward procedure. Logistic regression, Box-Cox regression, Violations of regression assumptions, Discriminant analysis and MANOVA.

Simultaneous Equation Models, Panel data analysis, Time series analysis- Smoothing Methodologies, ARIMA family of models, Non-linear time-series models, Multivariate Time-series models and Measures of Forecasting Accuracy.

Latent variables models- Principle component analysis, factor analysis, Structural equation modelling. Duration models- Hazard-Based Duration Models, Nonparametric, Semiparametric, Fully parametric, Time varying coefficients, Discrete-Time Hazard Models and Competing Risk models.

Count data models- Poison regression, negative Binomial regression models. Discrete outcome models- Probit regression, Multinomial Logit Model, Mixed MNL Models, Nested Logit Model (Generalised Extreme Value Model), Models of ordered Discrete Data. Discrete/Continuous Models- Econometric Corrections: Instrumental Variables and Expected Value Method. Econometric Corrections: Selectivity-Bias Correction Term, Discrete/ Continuous model structure.

References:

1. Washington, S.P., Karlaftis, M.G., Mannering, F.L., Statistical and Econometric Methods for Transportation Data Analysis, 2nd Edition, CRC Press, 2011.
2. Gujarati, D. N. (2009). *Basic econometrics*. Tata McGraw-Hill Education.
3. Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2013). Multivariate Data Analysis, 7/e. Pearson India.
4. Greene. W. (2010). Econometric Analysis. Pearson, ISBN0-13-139538-6
5. Wooldridge, J., M. (2012). Introductory Econometrics: A Modern Approach. 5th Edition, Cengage
   Publications, ISBN: 1-111-53104-8
6. Tabachnick, B. G., & Fidell, L. S. (2013). Using Multivariate Statistics, 6/e. Pearson Prentice
   Hall.

Course Outcomes:

Upon completion of this course, the students should be able to:

- develop deeper understanding of statistics, linear regression models and its limitations.
- construct simultaneous equation models and interpret the results.
- ascertain whether a generalized linear model can be used in a given situation and carry out statistical analysis.