B.Tech & B.Tech. +M.Tech
IV Year - I Semester

Course code	Category	Course Title	Hours per week		Internal Marks	External Marks	Total Marks	Credits
			L	P				
CV4101	PE	Professional Elective-III	4	0	30	70	100	3
CV4102	PE	Professional Elective-IV	4	0	30	70	100	3
CV4103	PE	Professional Elective-V	4	0	30	70	100	3
CV4104	OE	Open Elective-III	4	0	30	70	100	3
CV4105	OE	Open Elective-IV	4	0	30	70	100	3
CV4106	HSSE	Elective	4	0	30	70	100	3
CV4107	SC	Quality Evaluation of Civil Engineering Structures	1	2	50	50	100	2
CV4108	INT	Internship - II			50	50	100	2
							Total Credits	22

B.Tech & B.Tech. +M.TechIV
Year - II Semester

Course code	Category	Course Title	Internal Marks	External Marks	Total Marks	Credits
CV4201	PROJ	Project work	100	100	200	14
					Total Credits	14

Professional Electives

1. Hydraulic and Irrigation Structures
2. Matrix Methods of Structural Analysis
3. Introduction to Rock Mechanics
4. Advanced Design of Structures
5. Advanced Fluid Mechanics
6. Geo-Environmental Engineering
7. Remote Sensing and GIS Applications
8. Earth Retaining Structures
9. Repair and Retrofitting of structures
10. Railways and Harbour Engineering
11. Environmental Impact Assessment
12. Bridge Engineering
13. Industrial Waste Treatment
14. Traffic Engineering and Management
15. Finite Element Method of Analysis

Open Electives

1. Sanitary Engineering
2. Watershed Management
3. Elements of Earthquake Engineering
4. Prestressed Concrete Structures
5. Elements of Coastal Engineering
6. Sub-soil Exploration and Insitu Soil Testing
7. Air Pollution and Control
8. Design and Detailing of Reinforced Concrete and Steel Structures
9. Analysis and Design of Pavements
10. Project Planning and Management
11. Ground Improvement Techniques
12. Solid Waste Management

HSS Electives

1. Industrial Management & Enterprises
2. Organizational Behaviour
3. Operations Research

Professional Electives

16. Hydraulic and Irrigation Structures
17. Matrix Methods of Structural Analysis
18. Introduction to Rock Mechanics
19. Advanced Design of Structures
20. Advanced Fluid Mechanics
21. Geo-Environmental Engineering
22. Remote Sensing and GIS Applications
23. Earth Retaining Structures
24. Repair and Retrofitting of structures
25. Railways and Harbour Engineering
26. Environmental Impact Assessment
27. Bridge Engineering
28. Industrial Waste Treatment
29. Traffic Engineering and Management
30. Finite Element Method of Analysis

Open Electives

13. Sanitary Engineering
14. Watershed Management
15. Elements of Earthquake Engineering
16. Prestressed Concrete Structures
17. Elements of Coastal Engineering
18. Sub-soil Exploration and Insitu Soil Testing
19. Air Pollution and Control
20. Design and Detailing of Reinforced Concrete and Steel Structures
21. Analysis and Design of Pavements
22. Project Planning and Management
23. Ground Improvement Techniques
24. Solid Waste Management

HSS Electives

4. Industrial Management & Enterprises
5. Organizational Behaviour
6. Operations Research

B.Tech & B.Tech. +M.Tech	**IV Year - I**
SemesterCV4101	**PROFESSIONAL**
ELECTIVE - III CV 4102	**PROFESSIONAL**
ELECTIVE – IV CV 4103	**PROFESSIONAL**
ELECTIVE – V	
CV 4104	**OPEN ELECTIVE –IIICV**
4105	**OPEN ELECTIVE –IVCV**
4106	**HSS ELECTIVE**

CV 4107 QUALITY EVALUATION OF CIVIL ENGINEERING STRUCTURES

Course Objectives:

- To study various Non-destructive testing techniques to evaluate quality of concrete
- To impart knowledge regarding advanced quality evaluation techniques
- To understand various causes of degradation in steel structures
- To study different methods used to assess degree of field compaction
- To understand different methods of determining CBR of insitu soil
- To impart skills to check unevenness of pavements through various techniques

Course Outcomes:

At the end of the course student will be able to

- Evaluate homogeneity and strength of concrete using different NDT techniques
- Understand different techniques used to assess durability of concrete
- Select appropriate method to assess corrosion activity of steel
- Assess quality of compaction achieved in embankments and pavements
- Evaluate continuity and integrity of concrete piles
- Understand various methods used for quality evaluation of pavements

SYLLABUS

Introduction – Necessity of Non-Destructive Evaluation and Structural Health Monitoring; Fundamental differences between NDE and SHM philosophies; Causes of degradation in concrete and steel structures; General methods of NDT of civil engineering structures according to Indian Standards; Exposure to different techniques: Rebound Hammer, Ultrasonic Pulse Velocity, Resistivity meter, Poroscope, Half-cell potential cell, Profometer (Cover meter)

Evaluation of Field Compaction: Degree of Compaction, Relative Density, Rapid Moisture Meter, Proctors Compaction Needle.

Quality Evaluation of Casted Piles: Pile Integrity Test

Evaluation of Quality of Pavements: Field CBR test, Dynamic Cone Penetrometer, Determination of Unevenness of Pavement by Benkelman Beam Method, Rebound Deflection of Flexible Pavements, Bitumen Extraction Test.

CV4108 INTERNSHIP - II

B.Tech & B.Tech. +M.Tech IV Year - II Semester

CV4201 PROJECT WORK

PROFESSIONAL ELECTIVES

1. HYDRAULIC AND IRRIGATION STRUCTURES

Course Objectives:

- To study modes of failure, stability analysis and design of gravity dam and earth dams.
- To study various types of spillways and their suitability, energy dissipation below spillways.
- To study seepage theories and their applications in the design of weirs on permeable foundations.
- To study functions, types and suitable locations for canal falls, canal regulators and cross drainage works.
- To study about component parts and their functions.

Course Outcomes:

At the end of the course the student will be able to:

- Analyze the stability analysis and design of gravity dam and an earth dam.
- Suggest a suitable spillway at a dam site and understand the criteria for design of stilling basin for energy dissipation under spillway.
- Understand the functions and suitable locations of canal outlets, canal falls, canal regulators and cross drainage works and design of weirs.
- Understand the functions of component parts of a hydroelectric power scheme.

SYLLABUS

Storage Works: Classification of Dams, Factors Governing Selection of Types of Dam, Selection of Site, Preliminary Investigation.

Gravity Dams: Forces acting on a Gravity Dam, Stability Criteria, Modes of Failure – Elementary and Practical Profiles, Stability Analysis, Principal and Shear Stress – Construction Joints, Openings in Dams – Galleries, Foundation Treatment of Gravity Dam.

Earth Dams: Types, Foundation for Earth Dams, Design of Earth Dams, Causes for Failure of Earth Dams, Criteria for Safe Design, Phreatic Line, Seepage Analysis – Seepage Control Through Body and Foundation.

Spillways: Essential Requirements, Spillway Capacity, Components, Types of Spillways and Their Working, Design of Ogee Spillway, Energy Dissipation Below Spill Way, Scour Protection, Use of Hydraulic Jump as Energy Dissipater – Design of Stilling Basins – USBR and IS Standard Basins; Spillway Crest Gates – Different Types.

Diversion Head Works: Types, Location and Components, Effects of Construction of Weirs on Permeable Foundation, Bligh's, Lanes and Khosla's Theories, Method of Independent Variables, Design Principles of Weirs and Barrages, Design of Weirs on Permeable Foundations, Design of Vertical Drop Weir, and Silt Control Devices.
Regulation Works: Canal Falls – Definition, Necessity and Location, Classification of Falls, Design Principles of Syphon Well Drop, Notch Fall, Sarada Fall, Straight Glacis Fall; Offtake Alignment; Cross Regulator and Distributary Head Regulator – Design of Cross Regulator and Distributor Head Regulator.

River Training Works: River Training and its Objectives, Classification of River Training Works, Marginal Embankment, Guide Banks, Groynes, Cutoffs, Bank Pitching, Launching Aprons, Miscellaneous Types of River Training Works.
Water Power Engineering: Development of Hydro Power in India, Assessment of Available Power, Utilization Factor, Load Factor, Diversity Factor, Storage and Pondage; Types of Hydro Power Schemes; Components of Hydel Schemes – Fore Bay, Intake Structure, Trash Racks, Surge Tanks; Water Hammer Pressure, Substructure and Superstructure of Power House..

Text Bookss

1. Irrigation and Water PowerEngineering byPunmia, B.C. and P.B.B. Lal, Laxmi Publications Pvt. Ltd.
2. Irrigation Water Resources and Water Power Engineering by Modi, P.N., Standard Book House.
3. Irrigation and Hydraulic Structures by Garg, S.K., Khanna Publishers.

Reference Book

1. Hand book of Applied Hydrology,Chow, V.T., McGraw-Hill Book Co.of a hydel project.

2. MATRIX METHODS OF STRUCTURAL ANALYSIS

Course Objectives:

- Impart knowledge regarding matrix-based approach for linear elastic analysis of structures.
- Analyse beams by using Flexibility and Stiffness methods.
- Develop flexibility and stiffness matrices for 2-D frames.
- Determine deflections and forces in statically determinate and indeterminate structures using flexibility and stiffness methods.
- Analyse 2-D trusses by using flexibility and stiffness matrix methods.

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

- Understand basic concepts of matrix methods for analysing of structures.
- Develop flexibility and stiffness matrices for structural elements.
- Analyse various types of beams by using flexibility and Stiffness methods.
- Analyse 2-D trusses using flexibility and Stiffness methods.
- Analyse 2-D frames using flexibility and Stiffness methods.

SYLLABUS

Introduction to matrix methods: Introduction, coordinate systems, displacement and force transformation matrices, element and structure stiffness matrices, element and structure flexibility matrices, equivalent joint loads, stiffness and flexibility approaches.

Matrix methods for beams: Analysis of beams, fixed and continuous beam by flexibility method. Analysis of beams, fixed and continuous beams by stiffness method.

Matrix methods for plane truss problems: Analysis of 2-D trusses by flexibility method.Analysis of 2-D trusses by stiffness method.

Matrix methods for Plane Frames: Analyse of 2-D frames by Flexibility matrix methods.Analysis of 2-D frames by stiffness matrix methods.

Text Bookss

1. Matrix methods of Structural Analysis by G.S.Pandit and S.P.Gupta, Tata McGraw Hill Co..
2. Matrix Analysis of framed Structures by W Weaver and Gere, Van Nostrand Reinhold.

Reference Books

1. Advanced Structural Analysis by Devdas Menon, Narosa Publishing House, 2009.
2. Matrix Analysis of Structures by Asslam Kassimali, Brooks/Cole Publishing Co., USA, 1999.
3. Analysis of Indeterminate Structures by C.K Wang, McGraw-Hill.

3. INTRODUCTION TO ROCK MECHANICS

Course Objectives

- To study the classification and properties of rock mass
- To illustrate the rock exploration techniques required during subsoil investigation

- To acknowledge the importance of identification of defects in rock mass
- To study laboratory and insitu methods for determining strength and deformation characteristics of rocks
- To understand different methods of improving properties of rock mass

Course Outcomes

- Identify and classify the rocks based on their physical and mechanical properties
- Evaluate core recovery and RQD of rock mass
- Understand various methods for evaluating properties of intact rock and rock masses
- Select appropriate reinforcement technique for improving properties of rocks
- Understand the procedure of blasting in rocks

SYLLABUS

Introduction: Geological Formation of Rocks, Structural Geology, Classification of Rocks, Defects in Rock, Physical, Mechanical Properties of Rocks, Exploration Techniques – RQD and RMR, Laboratory Tests for Shear Strength, Tensile Strength, Flexural Strength, Elastic Constants, Field Tests – Test for Deformability, Shear Tests and Strength Tests

Improvement Techniques for Rock: Grouting, Rock Bolting, Rock Reinforcement - Mechanism, Types of Reinforcement, Steps Involved in Installation

Foundations on Rock, Rock Blasting– Explosives, Selection Criteria for Explosives, Steps Involved in Blasting

Text Books

1. Rock Mechanics for Engineers by B.P.Verma, Khanna Publishers

Reference Books

1. Rock Characterization, Testing and Monitoring by E.T.Brown, Pergamon Press, London, U.K
2. Rock Mechanics on the Design of Structures in Rock by Oberti and Duvalk, W. L. John Wiley & Sons.
3. Rock Mass Classification Systems – A Practical Approach in Civil Engineering by B.Singh and R.K.Goel, Elsevier Publisher.

4. ADVANCED DESIGN OF STRUCTURES

Course Objectives:

- To familiarise the students of with earth pressure theories and pressure theories and design of different types of retaining walls.
- To impart knowledge about the analysis and design of liquid retaining structure according to is code.
- To impart knowledge about the limit state design of plate girders used for long spans.
- To impart skills of analyzing and designing different types steel bridges subjected to different types of loads.
- To familiarize students with gantry girder and their design.

Course Outcomes:

Students will be able to

- Understand earth pressure theories, as well as the design and detailing of various retaining walls;
- Analyse and design circular, rectangular, and staging water tanks.
- Proportionate section of plate girder and design of bolted and welded plate girders as per is 800-2007 and understand curtailment of flange plates and, connection of flange angles to web and flange angles to flange plates.
- Compute design loads on the bridges and design deck type or through type girder bridges and bearings.
- Analyse and design steel elevated circular, rectangular and pressed steel water tanks.
- Performs analysis and design of gantry girders.

Retaining walls: types of retaining walls, forces on retaining walls, rankine and coloumb earth pressure theories (c and ϕ soils). Passive earth pressure, drainage of retaining walls. Stability requirements. Preliminary proportioning of cantilever retaining walls. Design of cantilever and counterfort retaining walls.

Water tanks: stress in concrete and steel in water tanks, modular ratio, impermeability requirements, tanks resting on ground and below ground of circular and rectangular shapes; elevated circular and rectangular tanks resting on maximum of 8 columns; design of staging of rectangular tanks. (Use of is – 3370 CODE)

Design of Reinforced concrete combined footings with and without Strap Beam.

Plate girders (bolted and welded): components of a plate girder, economical depth, proportioning of web and flanges, shear buckling resistance of web (simple post critical and

tension field methods), curtailment of flange plates, connection of flange angles to web and flange angles to flange plates.

Web stiffeners: design of bearing stiffeners. End panel design, design of intermediate stiffeners, connections.

Bridges: classification, loadings, deck type and through type bridges, plate girder bridges, design of stringers, cross girders, wind bracings.

Gantry girders: introduction - loading consideration – maximum load effect – selection of gantry girder – analysis and design of gantry girders.

Reference Books:

1. Limit state of design of reinforced concrete – p.c. Vergheese
2. Reinforced concrete limit state design – a.k. Jain.
3. Design of reinforced concrete structures – p. Dayaratnam
4. Design of steel structures by n. Subramanian, oxford university press.
5. Limit state design of steel structures – ramchandra and virendra gehlot, scientific publishers (india)
6. Limit state design of steel structures by s.k.duggal, mcgraw hilleducation private ltd.
7. Design of steel structures by k.s.sai ram, pearson education india.
8. Design of steel structures by limit state method as per is: 800-2007 – s.s. Bhavikatti, ik international publishing house, bangalore – 560 001.

5. ADVANCED FLUID MECHANICS

Course Objectives

- To impart knowledge regarding fundamental of laminar flow with an emphasis on steady laminar flow through pipes.
- To develop an understanding of fluid flow patterns and learns to use boundary layer theory.
- To understand the concepts of turbulent flow in pipes.
- To study in detail about drag and lift characteristics.
- To explain methods of dimensional analysis and the importance of their application to the field of fluid mechanics

Course Outcomes

Students will be able to

- Understand the derivation of governing equation for steady laminar flow through pipes along with understanding the basic concepts of laminar flow.
- To deal design aspects of turbulent flow analysis in pipes.
- Learn the concepts of boundary layer theory, flow separation theory along with drag and list concepts.
- Understand the dimensional analysis criteria to hydraulic problems and carryout model studies on hydraulic systems such as rivers, hydraulic structures and harbors.

SYLLABUS

Laminar flow: Equation of Motion for Real Fluids – Modifications in Equation of Motion, Stress Strain Relationships, Tangential Stress Terms. Plane Two- dimensional Flows – Steady Flow between Parallel Plates, Couette and Poiseuille Flows; Axisymmetric Flows – Flow through a Circular Annulus, Flow without and with Pressure Gradient – Hagen-Poiseuille Equation; Relationship between Friction factor and Reynolds Number for Laminar Flow through Pipes; Stokes law.

Navier-Stokes Equations (No Derivation) – N.S. equations for standard cases of Plane two Dimensional and Axisymmetric Flows.

Boundary Layer Theory: Theory of Boundary Layer – Characteristics of Laminar Boundary Layer – Boundary Layer growth over a Flat Plate (without pressure gradient) – Boundary Layer Thickness and its Characteristics – Displacement, Momentum and Energy Thicknesses; Stability Parameter; Laminar and Turbulent boundary layers.

Boundary Layer Separation – Mechanism of Separation, Control of B.L. Separation; Boundary Layer on Rough Surfaces – Laminar Sublayer, Shear Friction Velocity; Friction Drag.

Turbulent Flow: Critical Reynolds Number – Characteristics of Turbulent Flow – Mean and Fluctuating Components of Velocity. Analysis of Turbulent Flows – Shear Stress due to Turbulence –Velocity distribution for Hydrodynamically Smooth and Rough Pipes; Variation of Friction Factor in Turbulent Flow; Friction Factor for Commercial Pipes – Moody diagram.

Drag, Lift & Propulsion: Concepts of Drag and Pressure Distribution over Immersed Bodies – Drag and Lift – Deformation Drag, Friction Drag, Form Drag – Drag coefficient. Distribution of Fluid Pressure on immersed bodies –Distribution of pressure for two dimensional flow past a cylinder – von Kármán vortex trail, Eddy shedding; Drag of immersed bodies – Variation of Drag Coefficient with Reynolds Number – Drag on Cylinder – Resistance diagram for bodies of revolution; Drag Coefficient of Practical Bodies. Lift & Propulsion – Effect of Circulation in Irrotational Flow, Generation of Lift around a Cylinder, Magnus Effect, Computation of Lift

Force; Lift on Airfoil – Lift Coefficient and its Variation with Angle of Attack, Joukowsky Profile, Polar Diagram, Stall; Induced Drag.

Dimensional Analysis and Similitude: Fundamental Concepts of Dimensional Analysis – Importance of Dimensional Analysis & Model Study; Units and Dimensional Formulae for Various Engineering Quantities; Fourier Concept of Dimensional Homogeneity; Methods of Arriving at Dimensionless Groups – Non-dimensional Parameters; Rayleigh's Method; Buckingham π method – Buckingham modified method; Omitted and Superfluous variables; Examples in Dimensional Analysis – Capillary Rise, Drag on Cylinder, Resistance of a Ship, Discharge over a Sharp Crested Weir, Fall Velocity of a Sphere, Head Characteristics of a Pump, Thrust on a Propeller.
Similarity and Similarity Laws – Concepts of Similarity – Geometric, Kinematic and Dynamic Similarities; Modeling Criteria; Similarity Laws – Important Dimensionless Numbers – Reynolds Number, Froude Number, Mach Number, Euler Number, Weber Number;Application of Similarity Laws to Practical Problems – Bodies Completely Submerged in Fluids, Bodies Subjected to Gravity and Viscous Forces, River Models – Manning's Law; Distorted Models – Depth Distortion and Slope Distortion; Problems Related to Modeling of Spillways, Ships, Pumps and Turbines.

Text Books

1. Fluid Mechanics and Hydraulic Machinery by P.N.Modi and S.M. Seth, Standard Book House.
2. Fluid Mechanics by Jain, A.K., Khanna Publishers.

Reference Books

1. Engineering Fluid Mechanics by K.L.Kumar, S. Chand & Co.Ltd.
2. Hydraulic Machines by Jagadish Lal, Metropoliton Book Company.
3. Mechanics of Fluids, I.H.Shames,McGraw-Hill Professional.

6. GEO-ENVIRONMENTAL ENGINEERING

Course Objectives:

- To impart knowledge about solid wastes and MSW.
- To understand about soil pollution and remedies.
- To inculcate the ideas about waste containment and waste disposal facilities.
- To analyse the reasons for soil erosion and its effect on human activities.
- To describe the preventive measures including structure to control soil erosion and consequences.

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

- Understanding characterization of wastes provides various disposal and remediation measures.
- Creation of knowledge about landfill and its components for waste containment.
- Analysis of pollutants and their characterization helps in study of soil pollution and to propose various environment protective measures.
- Deriving knowledge about types of erosions and their controlling measures extends to various erosional features related to geological and geomorphological concern

SYLLABUS

Wastes: Source, Production and Classification of Wastes, Soil Pollution Processes, Waste Characterization, Physical Characterization, Problems due to Improper Disposal of Wastes, Waste Management Strategies.

Soil Pollution, Sources of Soil Pollution, Control of Soil Pollution.

Waste Disposal Facilities such as Landfills, Configuration or Types of Landfill, Components of Landfill, Layout of a Landfill Site, Stages of Decomposition of Waste in a Landfill, Landfill Planning and Design. Barrier Systems – Active Systems, Passive Systems, Vertical Barriers and their Types, Bottom Barriers, Reuse of Waste Materials, Contaminated Site Remediation.

Text Books

1. Geoenvironmental Engineering – Principles and Applications by Reddi, L. N., and Inyang, H. F., Marcel Dekker.

Reference Books

1. Geotechnical Practice for Waste Disposal by Daniel, D. E., Chapman and Hall, London.
2. Clay Barrier Systems for Waste Disposal Facilities by Rowe, R. K., Quigley, R. M. and Booker, J.R., E & FN Spon, London.

7. REMOTE SENSING AND GIS APPLICATIONS

Course Objectives:

- To introduce the basic concept and principles of Remote Sensing
- To illustrate solar energy interactions with atmosphere and with earth surface features
- To Know about different types of satellite and sensors.
- To Learn image analysis and apply for interpretation of satellite images

- To understand data types, data inputs and data analysis in GIS and Learning about map projection and coordinate system.
- To develop knowledge on RS and GIS applications in civil engineering.

Course Outcomes:

After completing this course, the student will have acquired the ability on the following.

- Understand the principle of remote sensing, develop ability to comprehend the energy interactions with atmosphere and earth surface features, spectral properties of various natural and cultural features.
- Understand types of satellite images and their characteristics and develop ability to choose appropriate sensor products for various remote sensing applications.
- Ability to perform image analysis and image interpretation.
- Understand spatial and non-spatial data features in GIS and know vector and raster data representation in GIS.
- Understand the map projections and coordinates systems and able to create thematic layers.
- Understand the integration of Remote Sensing and GIS and apply the knowledge to work in various application fields through spatial analysis.

SYLLABUS

Remote Sensing: Introduction, Basic components of remote sensing, electromagnetic radiation, electromagnetic spectrum, interaction with atmosphere, energy interaction with the earth surfaces, Sensors- types and characteristics, passive sensor, active sensor, platforms-airborne remote sensing, space borne remote sensing, data pre-processing, Important Remote Sensing Programme.

Geographic Information System: Introduction, key components, spatial data, raster data models, vector data models, raster versus vector, data input methods and editing, non-spatial data, map projections.

Image analysis: Introduction, elements of visual interpretations, digital image processing- digital image data formats-band interleaved by pixel, band interleaved by line, band sequential, image preprocessing, image rectification, image enhancement, image classification, supervised classification, unsupervised classification.

GIS analysis: Introduction, digital elevation models, RS and GIS data integration, overlay function-vector overlay operations, raster overlay operations, arithmetic operators, comparison and logical operators, conditional expressions, overlay using a decision table, some neighbourhood operations.

RS and GIS applications in Civil Engineering: Land cover and land use, urban applications, Hydrological studies, runoff modeling, flood zone delineation and mapping, groundwater prospects and recharge, reservoir storage estimation, water management, irrigation planning, drought monitoring, environmental impact assessment and other watershed studies.

Text Books

1. Remote Sensing And Image Interpretation By Thomas M. Lillesand And Ralph W. Kiefer, John Wiley And Sons Inc.
2. Gis By Kang Tsung Chang, Tmh Publications & Co.

Reference Books

1. Remote Sensing And Its Applications By Dr George Joseph.
2. Concepts & Techniques Of Gis By C.P.Lo Albert, K.W. Yonng, Prentice Hall (India) Publications.
3. Principles Of Geographical Information Systems – Peter A Burragh And Rachael A. Mc Donnell, Oxford Publishers 2004.

8. EARTH RETAINING STRUCTURES

Course Objectives:

- To recognize the need for soil retention systems in granular and cohesive soils
- To deepen the understanding of the concepts related to earth pressures and their distribution through classical theories.
- To differentiate between the lateral pressure distribution in braced cuts and retaining walls
- To impart skills to analyse and design retaining walls
- To analyse and design sheet pile walls in granular and cohesive soils

Course Outcomes:

At the end of the course student will be able to

- Compute the earth pressures acting behind the retaining structures, from different methods.
- Carry out analysis and design of the retaining walls for a given height of backfill
- Suggest the most appropriate type of retaining system to be adopted for a given site conditions.
- Develop earth pressure envelops for design of braced cuts and check their stability
- Perform design of anchored bulk heads

SYLLABUS

Earth Pressure: Basic Concepts, Rankine and Coulomb Earth Pressure Theories, Determination of Active and Passive Pressures: Culmann's Graphical Method, Logarithmic Spiral Methods, Friction Circle Method. Consideration of Surcharge, Seepage, Earthquake, Wave Effect, Stratification, Type of Backfill, Wall Friction and Adhesion.

Retaining Structures: Uses, Types, Stability and Design Principles of Retaining Walls, Backfill Drainage, Settlement and Tilting. Sheet Pile Walls: Types, Design of Cantilever Sheet Pile Walls in Granular and Cohesive Soils; Design of Anchored Sheet Pile Walls by Free and Fixed Earth Support Methods, Rowe's Theory of Moment Reduction, Design of Anchors.

Braced Excavations: Types of Sheeting and Bracing Systems, Lateral Earth Pressure on Sheeting in Sand and Clay, Design Components of Braced Cuts. Cellular Cofferdams: Types – Diaphragm and Circular Type, Design by TVA Method. Stability of Cellular Cofferdams, Cellular Cofferdams in Rocks and Soils.

Text Books

1. Foundation design by W. C. Teng, Prentice Hall

Reference Books

1. Basic and Applied Soil Mechanics by Gopal Rajan and A.S.R. Rao, New Age International Publishers.
2. Soil Mechanics in Engineering Practice by K.Terzaghi and R.B.Peck, John Wiley & Sons.
3. Foundation Analysis and Design by J. E. Bowles, Mc Graw-Hill Publishing Co.

9. REPAIR AND RETROFITTING OF STRUCTURES

Course Objectives:

- To learn various distress and damages to concrete and masonry structures
- To understand the importance of maintenance of structures
- To study the various types and properties of repair materials
- To assess the damage to structures using various tests
- To learn the importance and methods of substrate preparation
- To learn various repair techniques of damaged structures, corroded structures

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

- Understand the properties of fresh and hardened concrete.
- Know the strategies of maintenance and repair.
- Get an idea of repair techniques.
- Understand the properties of repair materials
- Understand the retrofitting strategies and techniques

Materials: Construction chemicals, Mineral admixtures, Composites, Fibre reinforced concrete, High performance concrete, polymer-impregnated concrete.

Techniques to test the existing strengths: Destructive and non destructive tests on concrete.

Repairs of Multistory structures: Cracks in concrete, possible damages to the structural element-beams, slab, Column, Footings, etc., Repairing techniques like Jacketing, Grouting, External prestressing, Use of chemical admixtures, Repairs to the fire damaged structures.

Foundation problems: Settlement of shallow foundations – repairs, sinking of piles, wells – repairs.

Corrosion of Reinforcement: Preventive measures – coatings –use of SBR modified cementitious mortar, Epoxy resin mortar, Acrylic modified cementitious mortar, flowing concrete.

Reference Books

1. "Deterioration, Maintenance and Repair of Structures" by Johnson, McGraw Hill.
2. "Concrete Structures: Repairs, water proofing and protection" by Philip H. Perkins, Applied sciences publications Ltd., London, pp.302.
3. "Durability of concrete structure: Investigation, Repair, Protection" Edited by Geoffmang., E. & FN SPON, An imprint of Chapman & Hall, pp.270.
4. "Deterioration, maintenance and Repair of structures" by Johnson, McGraw Hill, pp.375

10.RAILWAYS AND HARBOUR ENGINEERING

Course Objectives:

- To impart knowledge about the different modes of transportation like railways and harbours.
- To impart knowledge about the components of a railway track, its geometric design elements, rail fixtures and fastening etc.

- To familiarise the students about harbours and ports.
- To impart knowledge about the harbour phenomena like waves, tides, sediment transport, littoral drift etc.
- To familiarise the students about the components of harbours and ports like breakwaters etc.

Course Outcomes:
Students will be able to

- Understand and design the railway section incorporating geometric design elements like superelevation, analyzing safe speeds on the sections of railway track, transitional curves etc.
- Provide appropriate signals at station yards thereby reducing accidents.
- Design the features of a turnout like points and crossing.
- Design the facilities to be provided inside a harbour or port for safe navigation.
- Design the different navigational aids to be provided while navigation and also fixed navigational structures like lighthouses.

Railway Engineering I: Comparison of Railway and Highway transportation; Advantages of Railways; Classification of Indian Railways; Railway track components and their functions; Capacity of track; Gauges in Railway Track; Railway track cross-sections.

Railway Engineering II: Functions of Rails; Rail failures; Rail joints and Welding of rails; Creep of rails; Rail fixtures and fastenings; Sleepers; Ballast.
Geometric Design of track - Gradient, Super elevation, Curves, Widening of gauge on Curves.

Railway Engineering III: Points and Crossings - Turnout, Switches, Crossing and its types; Track junctions; Stations and yards; Signaling and Control system; Interlocking; track drainage and maintenance.

Harbour Engineering I: Types of water Transportation; Advantages and disadvantages of water transportation; Harbour Classification; Harbour site investigation and site analysis; Harbour size and depth.

Harbour Engineering II: Natural phenomenon- Tides, Wind, Waves, Currents, Littoral drift.
Harbour works- Break waters and their types; Harbour Components- Jetty, Piers, Wharves, Off-shore moorings.
Navigational Aids - Fixed navigational structures, Floating navigational aids.

Text Bookss

1. Railway Engineering by S.C. Saxena and S. Arora, Dhanpat Rai Publications Pvt. Ltd.

2. Dock & Harbour by .S.P.Bindra

Reference Books.

1. Railway Engineering by Rangwala.
2. Dock & Harbour by Birdie.

11.ENVIRONMENTAL IMPACT ASSESMENT

Course Objectives:

- To familiarise with EIA methodologies
- To impart knowledge on EIA case studies
- To input skills on prediction and assessment of air and noise environment
- To input skills for prediction and assessment of water and soil environment
- To familiarise with cultural and socio economic environment

Course Outcomes:

the student will be able to

- Understand the concept and methodologies of EIA
- Understand the procedure for environmental clearance
- Discuss the basic information on environmental attributes like air, water and noise
- Discuss the standards, impact assessment and mitigation
- Discuss the socio economic attribute, resettlement and rehabilitation issues

SYLLABUS

Concept of Environment – Definition of EIA and EIS – Elements of EIA – Guidelines for the Preparation of EIS – Governmental Policies for Environmental Protection.

Environmental Setting – Environmental Attributes – Air, Water, Soil, Noise, Ecological, Social, Economical, Cultural, Human and Aesthetic Aspects – Environmental Indices.

Methodology for the Identification of Impacts – Criteria for the Selection of Methods – Methodologies – Adhoc, Checklist, Overlaying, Matrix and Network Methods.

Prediction and Assessment of Impacts on – Air, Water, Soil, Noise, Ecological, Social, Economical, Cultural, Human Environments and Aesthetic Aspects.

Review of Environmental Impact Statement – Cost Benefit Analysis – Measures for Environmental Impact Mitigation and Control – Case Studies.

Text Books

1. Environmental Impact Assessment by Larry W. Canter. McGraw-Hill Co.
2. Environmental Impact Assessment Methodologies by Y Anjaneyulu, and Valli Manikkam,, BSP Books PVT Ltd.

Reference Books

1. Environmental Impact Assessment by R.K.Jain, L.V.Urban, G.S.Stacey and H.E. Balbach, McGraw-Hill Co.

12.BRIDGE ENGINEERING

Course Objectives:

- To equip the students with a thorough understanding of the behavior and design of bridges.
- To impart knowledge about components, classifications and choice of bridge type along with the investigation for bridges in detail.
- To give a clear idea of various IRC standard specifications for R.C.C road bridges.
- To develop skills to analyse and design short and medium span bridges using existing codes of practice, taking into account the structural strength, service life, and durability.
- To familiarise the design and Stability analysis of foundation for bridges.

SYLLABUS

Concrete Bridges: Introduction-Types of Bridges-Economic span length, Importance of site investigation in Bridge design -Types of loading-Dead load-Live load(IRC Standards)-Impact Effect-Centrifugal force-wind loads-Lateral loads-Longitudinal forces-Seismic loads-Frictional resistance of expansion bearings-Secondary Stresses-Temperature Effect-Erection Forces and effects-Width of roadway and footway-General Design Requirements.

Box culvert: General aspects, Design loads, Design of Box culvert subjected to IRC loading.

Solid slab Bridges: Introduction-Method of Analysis and Design of solid slab bridge subjected to IRC loading.

Beam & Slab Bridge (T-Beam Girder Bridge): General features – Design of interior panel of slab – Pigeaud's method – Analysis and design of T-beam longitudinal girder subjected to IRC loading – Analysis and design of Cross Girder.

Piers & Abutments: General features – Bed Block – Materials for Piers & Abutments, Types of piers – Forces acting on piers – Design and Stability analysis of piers – General features of Abutments – forces acting on abutments – Design and Stability analysis of abutments .

Course Outcomes:

At the end of the course, the student will be able to

- Discuss the IRC standard live loads and design the deck slab type bridges.
- Understands the structural responses to different kinds of loads.
- Perform the Analysis of box culverts for the given loading and detail the box culverts.
- Analyse and design solid slab bridge.
- Design and detail of T-Beam bridges.
- Design and check the stability of piers and abutments.

Text Bookss

1. "Essentials of Bridge Engineering", D. Johnson Victor, Oxford University Press.
2. "Design of Bridges", N.Krishna Raju, Oxford & IBH Publishing Co.Pvt.Ltd, New Delhi.

13.INDUSTRIAL WASTE TREATMENT

Course Objectives:

- Acquire knowledge on characteristics of waste water from various sources and its primary treatment.
- Impart knowledge about principles of biological waste treatment.
- Design the processes of different biological treatment units.
- Familiarize with the various principles in industrial waste treatment.
- Understand the manufacturing processes, treatment of wastes and disposal methods of various industries.

Course Outcomes:

At the end of the course student will be able to

- Understand characteristics of waste water and primary treatment process of waste water.
- Discuss the different principles of biological waste treatment.
- Understand the design processes of different biological treatment units.
- Understand the various principles involved in treatment of industrial wastes.
- Summarize the manufacturing processes, treatment of wastes and disposal methods of various industries.

SYLLABUS

Characteristics of waste water of specific industries, characteristics of treatment plant effluents, Effect of waste water on self-purification capacity of streams, Primary treatment of waste water.

Principles of biological waste treatment; Microbiological growth rate kinetic equations, sludge production, oxygen requirements, continuous flow treatment models. Aerobic treatment studies in continuous and semi-continuous reactors. Anaerobic treatment, studies, Nitrogen and Phosphoros removal.

Biological treatment facilities : Process designs of the following units w.r.t. Industrial Wastes; Activated sludge process; trickling filter; sludge degestion units; Aerated lagoons; Stabilization ponds (oxidation ponds); oxidation ditches (Paveer ditches); Rotating Biological contactor; Anaerobic filter.

Principles of Industrial waste Treatment: Waste reduction pretreatment of wastes, collection and segregation of wastes, reduction in volume and strength neutralization; equalization; proportioning.

Manufacturing processes, flowsheets; Characteristics and treatment of wastes and disposal methods of the following industries – Sugar, Dairy, Distillery, Paper, Tannery, Textile, Sheet, Fertilizer, Oil refinery and Petrochemicals.

Reference Books

1) Waste Water Treatment by M.N. Rao and A. K. Datta

14.TRAFFIC ENGINEERING AND MANAGEMENT

Course Objective:

- To impart knowledge about the traffic characteristics, traffic studies and analysis.
- To design the roadway facilities to achieve an efficient, free and rapid flow of traffic.
- To impart knowledge about traffic studies such as traffic volume studies, speed studies, accident studies etc.
- To explain the functions of traffic control devices and the design of intersections.
- To explain the different management measures to be implemented on roads to improve the capacity.

Course Outcomes:

Students will be able to

- Design the road way facilities with signs, signals, markings and islands so as to achieve efficient flow of traffic.
- Acquire knowledge about different traffic studies such as speed studies, parking studies, accident studies etc.
- Gain knowledge to design the road way facilities efficiently for future traffic in a planned manner.
- Design the traffic signals efficiently to have a continuous and orderly flow of traffic with last delays.
- Implement traffic management strategies such as one-way street, staggering of work hours etc. to minimize congestion on roads with higher traffic intensity.

SYLLABUS

Traffic Engineering: Introduction, Importance of Traffic Engineering under Indian conditions, Traffic characteristics, The Road user and the vehicle. Traffic Surveys: Speed, Journey Time & Delay Surveys, methods of measuring Spot speeds, methods of measurement of Running Speed and Journey Speed, moving observer method, Traffic volume studies – Types of Counts, Automatic devices, Presentation of traffic volume study data.

Origin & Destination Survey – Need for O – D surveys, Survey methods, Presentation of Results, Parking Surveys – Types of Parking surveys, Parking Space Inventory, Cordon Count, Questionnaire type parking usage Survey – Design of parking facility. Analysis and Interpretations of Traffic Studies.

Statistical methods for Traffic engineering - Mean, Standard Deviation and Variance. Traffic flow characteristics, Traffic Capacity studies – factors affecting practical capacity, Design Capacity and Level of Service, Passenger Car Unit. Accident Studies – Accident studies and records, Accident investigations, Measures for reduction in accident rates, Traffic Safety.

Relationship between Speed, Travel time, Volume, Density and Capacity. Traffic Operations – Traffic regulation, Traffic Control Devices, Intersections – Intersection At Grade – Channelized and Unchannelized intersections, Rotary intersections, Grade – separated Intersections, Grade – separated structures.

Traffic Management – Transportation system Management, Travel Demand Management Techniques, Traffic management measures.

Reference Books:

1. Highway Engineering By S.K. Khanna & C.E.G.Justo
2. Traffic Engineering and Transport Planning By L.R. Kadiyali.

15.FINITE ELEMENT METHOD OF ANALYSIS

Course Objectives:

- To familiarise with matrix methods.
- To introduce importance and applications of Finite Element Method (FEM).
- To impart knowledge of different mathematical Techniques used in FEM analysis.
- To implement the basics of FEM to relate stresses and strains.
- To learn the theory and characteristics of finite elements that represent engineering structures.

Course Outcomes:

At the end of the course student will be able to

- Analyse the response of structures by matrix methods.
- Understands the concepts behind formulation methods in FEM.
- Understands different mathematical Techniques used in FEM analysis.
- Develop element characteristic equation and generation of global equation of elements.
- Able to apply suitable boundary conditions to a global equation to find displacements, stress and strains induced

SYLLABUS

Matrix Methods of Analysis – Introduction, Analysis of Beams and Portal Frames (One Bay, One Storey Two Bay, Two Storey) by Stiffness Method and Flexibility Method.

Introduction: A Brief History of F.E.M, Need of the Method, Applications of FEM, Review of Basic Principles of Solid Mechanics, Basic Equation in Elasticity Equations of Equilibrium, Constitutive Relationship, Concept of Plane Stress, Plain Strain, Concept of Axi-Symmetric Elements. Concept of Energy Principles and Methods.

Basic Theory Relating to the Formulation of the Finite Element Method, Element Shapes, Nodes, Nodal Degree of Freedom, Node Numbering, Coordinate System (Local and Global), Convergence Requirements, Compatibility Requirement, Geometric Invariance.

Finite Element Analysis of Single Bar Element (One-Dimensional Problem) – Shape Functions, Derivation of Stiffness Matrix, Stress-Strain Relations – All with Reference to Bar Element and Trusses under Axial Forces.

Text Books

1. Structural Analysis – A Matrix Approach by G.S.Pandit and S.P.Gupta, Tata McGraw-Hill Publishing Co. Ltd.
2. Introduction to the Finite Element Method by C.S.Desai and J.F.Abel, Van Nostrand.
3. Finite Element Analysis by C.S.Krishnamoorthy, Tata McGraw-Hill Publishing Co. Ltd.

Reference Books

1. Introduction to Finite Elements in Engineering by Tirupathi R. Chandrupatla, Ashok D.Belegundu, Prentice-Hall of India Private Limited.
2. Finite Element Analysis by S.S.Bhavikatti, New Age International Publishers.
3. Basic Structural Analysis by C.S. Reddy, Tata McGraw-Hill, New Delhi.
4. Finite Element Methods for Engineers by Reger, T. Fenuer, The Macmillan Ltd., London

OPEN ELECTIVES

1. SANITARY ENGINEERING

Course Objectives:

- To familiarize the concept of sanitation and Estimation of Sewage Flow.
- To impart knowledge on design of sewers and hydraulics of sewers.
- To expose the necessity of sewage characteristics by physical, chemical and biological examinations.
- To create knowledge on BOD, COD and treatment of sewage water.
- To input knowledge on filters and design of filters.
- To make acquainted with the principles and design of sludge treatment.

Course Outcomes:

The students will be able to

- Understand the necessity of sanitation and estimate the sewage flow in drainages.
- Design the sewers and also appurtenances in sewerage.
- Analyze the physical, chemical and biological characteristics of sewage water.
- Evaluate the content of bod, cod and process involving in the treatment of sewage water.
- Design sludge treatment.

SYLLABUS

Introduction to sanitation – systems of sanitation – relative merits & demerits – collection and conveyance of waste water – sewerage – classification of sewerage systems- Estimation of sewage flow and storm water drainage – fluctuations – types of sewers – Hydraulics of sewers and storm drains– design of sewers – materials for sewers- appurtenances in sewerage – cleaning and ventilation of sewers—safety of sewer workers.

Storm sewers- design: Pumping of wastewater – Pumping stations – location – components parts– types of pumps and their suitability with regard to wastewaters. House Plumbing: plumbing systems of drainage-sanitary fittings and other accessories– single stack system- one pipe and two pipe systems – Design of building drainage.

Bacteriology of sewage: Sewage characteristics – Physical, Chemical and Biological Examination– decomposition- cycles of decomposition-– Sampling and analysis of wastewater – BOD-COD-Treatment of sewage - Primary treatment: Screens-grit chambers – grease traps – floatation – sedimentation – design of primary and pretreatment units.

Secondary treatment: Aerobic and anaerobic treatment process-comparison.

Suspended growth process: Activated Sludge Process, principles, designs, and operational problems, modifications of Activated Sludge Processes, miscellaneous methods, Oxidation ponds, Oxidation ditches, Aerated Lagoons.

Attached Growth Process: Trickling Filters – mechanism of impurities removal- classification– filter problems – design and operation-recirculation. RBCs, Fluidized bed reactors, sewage disposal methods.

Anaerobic Processes: Septic Tanks and Imhoff tanks-Principles and Design-sludge treatment and disposal-Fundamentals of UASB. Biosolids (Sludge): Characteristics- thickening – digestion,drying and sludge disposal.

Text Books

1. Wastewater Engineering Treatment and Reuse by Metcalf & Eddy, Tata McGraw-Hill edition.
2. Environmental Engineering by Peavy, H.S., Rowe, D.R., and Tchobanoglous, G. McGraw-Hill international edition
3. Environmental Engineering. II: Sewage Disposal and Air Pollution Engineering, Khanna Publishers.

Reference Books

1. Environmental Engineering –II: Sewage disposal and Air Pollution Engineering, by S.K.Garg, Khanna Publishers
2. Water Supply and Sanitary Engineering by G.S.Birdie and J.S.Birdie, Dhanpat Rai Publishing Company.

3. Water Supply Engineering by P.N.Modi, Standard Book House.
4. Water Supply Engineering by B.C. Punmia, Ashok Kumar Jain, Arun Kumar Jain, Laxmi Publications (P) Ltd.

2. WATERSHED MANAGEMENT

Course Objectives:

- To give an overview of watershed management and principles of WSM.
- To impart knowledge on water resources and conjunction use of ground water and surface water to meet water demand.
- To impart knowledge on river basin watershed management and ground water management.
- To expose students about social aspects of WSM such as public aspects participation and integrated development.
- To emphasis on conservation of water through recycle and reuse of waste water, water harvesting.
- To explain the interference of integrated watershed management for sustainable development.
- To expose students to applications of RS and GIS for watershed management.

Course Outcomes:

At the end of the course the student will be able to:

- Plan for sustainable development by proper use of all available water resources of a watershed for optimum production with minimum hazards to natural resources.
- Determine the various solutions to meet the water demand.
- Implement damage mitigation measures to control soil erosion.
- Adopt appropriate techniques or methods for water harvesting.
- Knowledge on determining effective watershed modeling.

SYLLABUS

Principles of Watershed Management: Basics concepts, Hydrology and water availability, Surface water, Groundwater, Conjunctive use, Human influences in the water resources system, Water demand, Integrated water resources system

River basins Watershed Management Practices in Arid and Semi-arid Regions, Watershed management through wells, Management of water supply - Case studies, short term and long term strategic planning

Conservation of Water: Perspective on recycle and reuse, Waste water reclamation

Social Aspects of Watershed Management: Community participation, Private sector participation, Institutional issues, Socio-economy, Integrated development, Water legislation and implementations, Case studies

Sustainable Watershed Approach: Sustainable integrated watershed management, natural resources management, agricultural practices, integrated farming, Soil erosion and conservation

Water Harvesting: Rainwater management - conservation, storage and effective utilization of rainwater, Structures for rainwater harvesting, roof catchment system, check dams, aquifer storage

Applications of Geographical Information System and Remote Sensing in Watershed Management, Role of Decision Support System in Watershed Management.

Text Books:

1. Murthy, J.V.S., Watershed Management in India, Wiley Eastern, New Delhi, 1994.

Reference Books:

1. Murty, J.V.S., Watershed Management, New Age Intl., New Delhi 1998.
2. Allam, G.I.Y., Decision Support System for Integrated Watershed Management, Colorado State University, 1994.
3. Vir Singh, R., Watershed Planning and Management, Yash Publishing House, Bikaner, 2000.
4. American Society of Civil Engineers, Watershed Management, American Soc. of Civil Engineers, New York, 1975.

3. ELEMENTS OF EARTHQUAKE ENGINEERING

Course Objective:

- To give the foundations of many basic engineering principles connected to earthquake engineering.
- To introduce philosophy of seismic design with emphasis on strength, stiffness and ductility effects.
- To provide hands-on experience with the application of engineering concepts in the field of earthquake engineering.
- To apply scientific and technological principles of building planning, analysis, and design in accordance with earthquake design philosophy.
- To train the students to analyze earthquake characteristics and associated effects on structures.

Course Outcomes

Upon completion of this course Students will

- Acquires knowledge about relevant concepts of structural dynamics for single-degree-of-freedom and multiple-degree-of-freedom systems.
- Identifies key elements, causes of earthquakes, different seismic zones and differentiate between intensity and magnitude of earthquake.
- Understands the characteristics of response spectrum and evaluates structural response.
- Define the basic concepts for the design and evaluation of seismic performance of buildings

SYLLABUS

One Degree Systems: Undamped systems, various forcing functions damped systems, Response to pulsating force, Support motion. Lumped Mass Multidegree System: Direct determination of natural frequencies, Characteristic shapes, and multistory rigid frames subjected to lateral loads, damping in multi degree systems.

Earthquakes, Epicenter, Hypocenter and earthquake waves, Measurement of ground motion, Seismic regions, Intensity and Isoseismals of an earthquake, Magnitude and energy of an earthquake, Consequences of earthquakes, Seismic zoning.

Earthquake Response of Linear Systems: Earthquake excitation, Equation of motion, Response quantities, Response history, Response spectrum concept, Deformation, Pseudo-velocity, and Pseudo-acceleration, Response spectra, Peak structural response from the response spectrum, Response spectrum characteristics

Earthquake analysis of Multistory buildings: By seismic coefficient method and Response spectrum method, Base shear, Fundamental period of buildings, Distribution of forces along the height

Text Books

1. Dynamics of Structures, Theory and Applications to Earthquake Engineering by Anil K. Chopra, Prentice Hall of India.
2. Elements of Earthquake Engineering" by Jaikrishna and Chandrasekharan, Saritha Prakasham, Meerut.

Reference Books

1. Earthquake resistant design of structures" by S.K.Duggal, Oxford University Press.
2. Earthquake resistant design of structures" by Pankaj Agarwal and Manish Shrikhande, Prentice Hall of India Pvt. Ltd.

4. PRESTRESSED CONCRETE STRUCTURES

Course Objectives:

- To familiarise with different methods of Prestressing and Pretensioning and their practical applications.
- To evaluate the short-term and long-term losses in prestressing and design prestressed structures considering these losses.
- To learn how to analyze and design flexural members under service and ultimate loads.
- To learn how to design structural elements for shear, torsion, anchorage and end block.
- To discuss and appraise the recent advances in the prestressed concrete technology including the use of advanced materials and application of new technologies.

Course Outcomes:

On completion of this course, the student will be able to

- Understand the basic theories and the fundamental behaviour of prestressed concrete.
- Ability to apply the fundamental knowledge to the solution of practical problems.
- Asses the combined stresses induced by prestress and applied loads using basic concepts of analysis, equivalent load method and load balancing approach.
- Analyse uncracked and cracked prestressed concrete sections.

SYLLABUS

Introduction, Basic Concepts of Prestressing, Need for High Strength Steel and Concrete, Advantages of Prestressed Concrete; Materials for Prestressed Concrete, High Strength Concrete and High Strength Steel. Prestressing Systems (1) Freyssinet System (2) Gifford Udall (3) Magnel-Blatan System, Tensioning Devices, Anchoring Devices. (D) Pretensioning and Post Tensioning

Prestressing Losses, Elastic Shortening, Loss due to Shrinkage, Loss due to Creep, Loss due to Friction, Loss due to Curvature etc.; I.S. Code Provisions

Analysis of Prestressed Members, Assumptions, Pressure or Thrust Line; Concept of Load Balancing, Cable Profile, Kern Distance, Stress in Tendons as Per IS 1343, Cracking Moment. Deflection of Prestressed Concrete Beams

Limit State Design of Flexural Members, Stresses, I.S. Code Provisions, Design of Symmetrical Beams, Design of Prestressed Concrete Poles, Design for Shear, I.S. Code Provisions.

Transfer of Prestress (Pretensioned Members), Transmission Length, Bond Stress, Transverse Tensile Stress, End Zone Reinforcement, Flexural Bond Stress, I.S. Code Provisions.

Anchorage Zone in Post Tensioned Members, Stress Distribution in End Block, Guyon's Method of Approach of Analysis of End Block (not more than 2 Cables).

Text Books

1. Prestressed Concrete by N.Krishna Raju., Tata McGraw-Hill Education

Reference Books

1. Prestressed Concrete by N.Rajagopalan, Alpha Science International.
2. Prestressed Concrete by P. Dayaratnam, Oxford and IBH Publishers.
3. Design of Prestressed Concrete Structures by T.Y. Lin and Ned. H. Burns, Wiley India.

5. ELEMENTS OF COASTAL ENGINEERING

Course Objectives

- To familiarize the students about the coastal engineering and coastal processes.
- Making student to understand about the generation and propagation of surface gravity waves, tides, storm surges and Tsunamis.
- To import the skills of analysing the wave transformations and breaking processes.
- To develop the skills to estimate wave forces.
- To develop the skill in analysing the different types of coastal protection structures.

Course Outcomes

Students will be able to

- Understand the different types of coastal processes, beaches, and landforms.
- Learns different types of wave theories and prediction models
- Understands wave transformations and wave breaking
- To familiarize the basic governing equations for the design of coastal protections structures.
- Analyse the wave forces on marine structures.

SYLLABUS

Introduction, General Design Considerations for Coastal Engineering. Long Period Waves: Tides, Seiches, Tsunamis, Storm Surge and Wind Set Up.

Solutions of Linear Wave Equation for Progressive and Standing Waves – Pressure Velocity Fields – Surface Profile and Dispersion Relationship – Principle of Super Position – Wave Energy, Energy Flux and Energy Principle – Group Velocity.
Wave Mechanics. Celerity and Group Velocity. Wind Generated Waves. Wave Statistics.

Wave Transformation: Shoaling, Refraction, Diffraction and Reflection. Wave Breaking Criteria. Wave Forecasting for Deepwater Waves.

Beach Profiles and Surf Zone Wave Breaking. Sediment Transport. Impacts of Coastal Structures on Shoreline Changes. Seawalls, Breakwaters, Groins, Jetties, Wharves.

Wave Forces on Walls. Design of Breakwaters: Rubble Mound-Type, Wall-Type, Structural Cross-Section.
Wave Forces on Piles – Basic Assumptions – Values of the Inertia and Drag Coefficients and Their Dependence on the Wave Theory used.

Text Books

1. Water Wave Mechanics for Engineers and Scientists by R.G.Dean and R.A.Darlymple, World Scientific Publishers.
2. Coastal Hydrodynamics by J.S.Mani. PHI Publishers 2nd Edition.

Reference Books

1. Basic Coastal Engineering by R.M.Sorense, 3rd Edition, Springer.
2. Coastal Engineering Manual (CEM). US Army Coastal Engineering Research Center, 2002-2006. (Download from CECIL or USACE website).

6. SUBSOIL EXPLORATION AND INSITU SOIL TESTING

Course Objectives:

- To understand the objectives and stages of subsoil exploration
- To study different methods of soil exploration
- To understand the importance of different types of soil samples used for assessing its properties
- To analyze and interpret the field test data to characterize subsoil
- To prepare a subsoil investigation report

Course Outcomes:

The Students will be able to

- Select the appropriate method of exploration and depth of exploration for a given project at a given construction site
- Understand different methods of boring and their suitability
- Distinguish between thick and thin-walled samplers
- Plan and interpret in-situ soil tests data to evaluate the bearing capacity of soil
- Plan subsoil investigation program and prepare corresponding bore logs and investigation report

SYLLABUS

SUBSOIL EXPLORATION: Introduction, Objectives of soil exploration, Stages in Subsoil exploration: Reconnaissance, Preliminary and Detailed investigations; Geophysical Methods: Seismic, Electrical Resistivity Methods; Depth and extent of soil exploration, Methods of exploration: Exploration pits, Boreholes, Methods of Boring: Auger Boring, Wash Boring, Rotary Drilling, Percussion Drilling, Core drilling; Types of soil samples: Disturbed and Undisturbed samples, Thick and Thin-walled samplers.

IN-SITU SOIL TESTING: Standard Penetration Test, Static Cone Penetration Test, Dynamic Cone Penetration Test, In situ Vane Shear Test, Observation of Groundwater table, Preparation of Borelogs and Subsoil investigation report.

Text Books

1. Basic and Applied Soil Mechanics by Gopal Ranjan and A.S.R. Rao, New Age International Publications, New Delhi.
2. Soil Mechanics and Foundation Engineering by Dr.K.R.Arora, Standard Publishers Distributors, New Delhi.

Reference Books

4. Head, K. H., Manual of Soil Laboratory Testing, volume 1 to 3, 1981
5. Compendium of Indian Standards on Soil Engineering Parts I and II, 1987 – 1988.

7. AIR POLLUTION AND CONTROL

Course Objectives:

- To provide a general understanding of air quality and its impact on humans, materials, properties, and the local and global effects of air pollution on plants.
- To study the function and transport of air pollutants and their measurement methods.

- Study of sampling types and methods for ambient air and stack.
- Study of macro and micrometeorology for understanding the dispersion of pollutants
- To discuss different types of air pollution control devices and their design principles and limitation.

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

- Classify and identify the sources of air pollutants
- Assess the effects of air pollutant on human health and environment.
- Apply and illustrate the importance of various air pollution dispersion models.
- Evaluate the air quality and relate it with air pollution regulation
- Design various air pollution control equipment and evaluate its use.

SYLLABUS

Air Pollution and its definition – Factors influencing air pollution – Classification of pollutants particulates – Gases-Sources of pollution – Air qualities standards – effects – Location of Industries.

Meteorology – Wind roses – lapses rates – mixing depth atmospheric dispersion – plume behavior, accumulation, estimation of pollutants – Effective stack height.

Air Pollution effects on human beings, animals, plants and materials – Air Pollution Episodes in India and abroad.
Ambient air quality monitoring and stack monitoring.

Control of air pollution – Removal of pollutants – particulate and gaseous – Air pollution control equipments (units) such as settling chamber, cyclones, wet scrubbers/collectors, scrubbers, centrifugal scrubbers spray towers, packed beds, electrostatic precipitators, after burners-absorption – adsorption – Diffusion.

Reference Books

1) Air Pollution Control Technology by T. Painter.
2) Elements of Air Pollution Control by Prof. T. Shivaji Rao.
3) Air Pollution Control by K.V.S.G. Murali Krishna.
4) Fundamentals of Air Pollution by Dr. B.S.N. Raju, Oxford & I.B.H.

8. DESIGN AND DETAILING OF REINFORCED CONCRETE ANDSTEEL STRUCTURES

Course Objectives:

- Know the design of various types of retaining walls with detailing.
- Familiarize with the design and detailing of circular and rectangular water tanks.
- Design combined footings including detailing.
- Design plate girders and gantry girders with detailing.
- Analyse and design web stiffeners and bridges.

Course Outcomes:

At the end of the course, the students will be able to

- Analyze and design various types of retaining walls along with detailing.
- Analyze and design circular and rectangular water tanks along with detailing.
- Design combined footings including detailing.
- Analyze and design plate girders and gantry girders along with detailing.
- Design web stiffeners and bridges including detailing.

SYLLABUS

REINFORCED CONCRETE STRUCTURES:

Design and detailing of cantilever and counterfort retaining walls.
Design and detailing of rectangular and circular water tanks.
Design and detailing of combined footings.

STEEL STRUCTURES:

Design and detailing of plate girders.
Design and detailing of web stiffeners.
Design and detailing of gantry girders.
Design and detailing of bridges.

9. ANALYSIS AND DESIGN OF PAVEMENTS

Course Objectives:

- To familiarise the students with types of pavements and stress distribution for theoretical and actual subgrade conditions.
- To impart knowledge about design principles and methods for flexible and rigid pavements.

- To impart knowledge of concrete block pavements for different traffic loading conditions.
- To impart knowledge of environmental effects and influences on pavement condition.
- To impart knowledge of pavement management systems including overlays and maintenance.

Course Outcomes:
Students will be able to

- Understand stress distribution in pavements for different traffic loading conditions.
- Understand concrete block pavements with types of pavement distresses.
- Understand pavement instrumentation and condition with origin and remedy.
- Understand roughness and skid resistance in different environmental conditions.
- Understand pavement overlays and maintenance activities to be conducted for both Flexible and Rigid pavements.

SYLLABUS

Pavement types, stress distribution pavements - theoretical and actual Subgrade conditions and traffic loading. Design principles and methods for flexible and rigid pavements.

Design of Concrete block pavements.

Evaluation of pavement condition, pavement instrumentation: Types of pavement distresses, their origins and remedy.

Roughness and skid resistance. Environmental effects and influences. Pavement maintenance, overlays.

Reference Books:

1. Pavement Analysis and Design, second edition, by Yang H. Huang, Prentice Hall publishers.
2. Shell Pavement Design Manual - asphalt pavements and overlays for road traffic, by Nilanjan Sarkar, Ooms Avenhorn Holding India Pvt.Ltd;
3. Highway engineering by Khanna & Justo .

10. PROJECT PLANNING AND MANAGEMENT

Course Objectives:

- Enable students to understand importance of planning and management of construction projects and different elements of a construction management.

- Impart skills of network techniques in solving construction industry projects.
- Explore students to understand updating, resource leveling and smoothening of construction projects.
- Enable students to learn about contracts, tenders and various works and works measurement standards.
- Familiarize with the labour problems and labour legislation in India.

Course Outcomes:

The students will be able to

- Understand importance of planning, scheduling and controlling the construction projects.
- Draw the bar charts, networking diagrams using CPM and PERT to assess the completion time of the project.
- Understand and know the various types of contracts and works related to construction projects.
- Understand the significance and concept of scientific construction management, labour problems in construction projects.
- Discuss various labour problems and labour legislation in India.

SYLLABUS

PERT and CPM : Introduction : Origin of PERT and CPM, Planning, Scheduling and controlling Bar charts, Milestone charts, weaknesses in Barcharts, PERT and CPM networks – Comparison, Event, Activity, Rules for drawing networks, Numbering the events (Fulkerson's law : Dummy activities, Time estimate-Expected time, Earliest allowable occurrence time, Latest allowable occurrence time, slack, project duration, probability of completion, Start and Finish time estimates, Floats, Project scheduling, Critical and sub-critical path.

Cost analysis / updating / resource scheduling: Cost Analysis direct and indirect costs, operation time, Normal and crash points, optimising project cost, crash limit, Free float limit, Optimisation. Updating – Process of updating; when to update, Resource scheduling – Resource smoothening. Resource levelling, circle notation and arrow notation.

Contracts: Contracts – Element of contract, offer acceptance and consideration, valid contract, Department execution of works, Master Roll Form 21. Piece work Agreement form, work order; Contract system with tenders – Definitions – Contract, Contractor, Quotation, Earnest money, Security money, Tender, Tender notice, Tender form, Bidding procedure, Irregularities in Bidding, award, Types of contracts – Lumpsum contract; Lumpsum and schedule contract, Item rate contract, sub-contracts, joint ventures, Arbitration Disputes and claim settlement.

Management – Scope of the Construction Management, Significance of Construction management, Concept of Scientific Management, Qualities of Manager, Organization – Authority, Policy, Recruitment process and Training Development of Personnel Department.

Labour problems, Labour legislation in India, Workmen compensation Act 1923, and subsequent amendments, Minimum Wages Act 1948.

Reference Books

1. PERT and CPM – L. S. Srinath.
2. PERT and CPM – Punmia.
3. Estimating and Costing – B.N. Dutta.
4. Construction Management and Planning – Guna and Sen Gupta, B.

11. GROUND IMPROVEMENT TECHNIQUES

Course Objectives:

- To study the need and importance of ground improvement techniques
- To understand various methods adopted for stabilizing different types of soils
- To study different methods of in-situ densification of soils
- To understand the suitability and applications of grouting technique
- To impart knowledge about the concept of reinforced earth and applications of geosynthetics in reinforced soil structures

Course Outcomes:

At the end of the course student will be able to

- Identify the problem and suggest suitable method to improve soil characteristics
- Understand the effectiveness of radial consolidation in densification of clays
- Illustrate the construction methods for stabilizing soils using lime and cement
- Perform analysis and design reinforced earth retaining walls
- Design suitable ground improvement system in weak soils

SYLLABUS

In-situ Densification Methods in Granular Soils: Introduction of Vibration at the Ground Surface, Impact at the Ground Surface, Vibration at Depth, Impact at Depth.

In-situ Densification Methods in Cohesive Soils: Introduction, Preconsolidation Preloading using Sand Drains, Sand Wicks, and Geodrains/Band drains, Forced Vacuum Preconsolidation, Stone and Lime Columns, Thermal Methods.

Grouting: Objectives, Suspension, Emulsion and Solution Grouts, Categories of Grouting, Grouting Equipment, Stage Grouting in Soils by Tube-a-Manchettee, Ascending and Descending Stage Grouting, Hydro fracture, Grout Control

Reinforced Earth: Principles, Components of Reinforced Earth – Fill, Reinforcing Material and Facing, Evaluation of Interfacial Friction of Fill and Reinforcing Material, Applications of Reinforced Earth, Design Principles of Reinforced Earth Walls
Geotextiles: Introduction, Types of Geotextiles; Functions and their Application, Tests for Geotextiles

Soil Stabilization: Objectives, Methods of Stabilisation, Mechanical Stabilization: Proportioning of Materials by Rothfutch's Method, Factors affecting Mechanical Stabilization, Cement and Lime Stabilization: Mechanisms, Engineering Benefits, Factors affecting Cement and Lime Stabilization, Construction Techniques, Bituminous Stabilization: Types of Soil – Bitumen, Factors affecting Bituminous Stabilization of Soils, Construction Methods.
Deep Mixing of Soils with Lime/Cement: Lime-soil Columns, Soil-Cement Columns, Construction Methods, Applications.

Stone Columns: Introduction, Construction Methods – Vibroflotation Technique and Rammed Stone Column, Functions and limitations.

Text Bookss

1. Ground Improvement Techniques, P.Purushothama Raj, Lakshmi Publications (P) Ltd.

Reference Books

1. Engineering Principles of Ground Modification, Monfred R Hausmann,Mc Graw-Hill Publishing Co.
2. Highway Engineering, Khanna S.K. and Justo C.E., Nem chand Publications.

12. SOLID WASTE MANAGEMENT

Course Objectives:

- To familiarise the student on the sources and types of solid wastes
- To impart knowledge of solid waste management principles
- To input knowledge on waste segregation methods
- To develop skills of composting and familiarise with incineration methods
- To impart knowledge of waste disposal by sanitary landfill

Course Outcomes:

Upon successful completion of this course students will be able to:

- Gains the knowledge about the sources and types of solid wastes.
- Evaluate the characteristics of municipal solid waste.
- Analyse the problems due to improper disposal of solid waste and understand the integrated solid waste management options.
- Explain the merits and demerits of composing and incineration.
- Perform the analysis and design of sanitary landfill.

SYLLABUS

Introduction: Definition of Solid Waste, Garbage, Rubbish–Sources and Types of Solid Wastes. Characteristics of Solid Wastes: Physical, Chemical and Biological Characteristics– Problems due to Improper Disposal of Solid Waste.

Solid Waste Management: Definition– Reduction, Reuse, Recycling and Recovery Principles of Waste Management – Functional Elements of Solid Waste Management – Waste Generation and Handling at Source – Collection of Solid Wastes – Collection Methods and Services– Guidelines for Collection Route Layout.

Transfer and Transport of Wastes: Transfer Station – Processing and Segregation of the Solid Waste – Various Methods of Material Segregation.

Processing and Transformation of Solid Wastes: Composting: Definition–Methods of Composting – Advantages of Composting – Incineration: Definition – Methods of Incineration– Advantages and Disadvantages of Incineration.

Disposal of Solid Waste: Volume Reduction, Open Dumping, Land Filling Techniques. Landfills: Classification–Design and Operation of Landfills, Land Farming, Deep Well Injection.

Text Books

1. Integrated Solid Waste Management: Engineering Principles and Management Issues by George Tchobanoglous, Hilary Theisen, Samuel A Vigil. McGraw-Hill Series in Water Resources and Environmental Engineering.
2. Environmental Engineering by Howard S.Peavy, Donald R.Rowe and George Techobanoglous.

HSS ELECTIVES

1. INDUSTRIAL MANAGEMENT AND ENTREPRENEURSHIP
(Effective from the admitted Batch 2021-2022)

Course Objectives:

- To familiarize the students with the concepts of Management.
- To relate the concepts of Management with industrial organizations.
- To explain the factors affecting productivity and how productivity can be increased in an Industrial undertaking.
- To set forth a basic framework for understanding Entrepreneurship.

Course Outcomes:

On completion of the course, the students will be able to:

- Understand the roles, skills and functions of management.
- Distinguish the different types of business organizations.
- Identify the factors involved in Production Operations Management.
- Diagnose organizational problems and take suitable decisions.
- Establish good Human Resource Management practices.
- Acquire necessary knowledge and skills required for organizing and carrying out entrepreneurial activities.

SYLLABUS

Basic Concepts of Management: Management: - Definition, Nature and Importance; Functions of the Management; Levels of Management; F.W Taylor's Scientific Management; Henry Fayol's Principles of Management;

Forms of Business Organizations: Introduction, Types of Business organizations: Private Sector- Individual Ownership, Partnership, Joint stock companies and Co-Operative organizations; Public sector- Departmental Organizations, Public Corporations and Government Companies; The Joint sector Management.

Production and operations Management: Plant location- Factors to be considered in the selection of Plant location; Break - even analysis- Significance and managerial applications; Importance of Production Planning and Control and its Functions; Human Resource Management and Functions of Human Resource Manager (in brief); Functions of Marketing; Methods of Raising Finance.

Entrepreneurship: Definition, Characteristics and Skills, Types of Entrepreneurs, Entrepreneur vs. Professional Managers, , Growth of Entrepreneurs, Nature and Importance of Entrepreneurs, Women Entrepreneurs, Problems of Entrepreneurship.

Entrepreneurial Development and Project Management: Institutions in aid of Entrepreneurship Development, Idea generation: Sources and Techniques;, Stages in Project formulation ; Steps for starting a small enterprise - Incentives for Small Scale Industries by Government.

Text Books:

1. Sharma, S.C, and Banga, T.R., Industrial Organization & Engineering Economics, Khanna Publishers, Delhi, 2000.
2. Vasant Desai, The Dynamics of Entrepreneurial Development and Management (Planning for future Sustainable growth), HImalayan Publishing House, 2018.

Reference Books:

1. Aryasri, A.R., Management Science, McGraw Hill Education (India Private Limited , New Delhi 2014.
2. Sheela, P., and Jagadeswara Rao, K., Entrepreneurship, Shree Publishing House, Guntur, Andhra Pradesh, 2017.

2. ORGANIZATIONAL BEHAVIOUR (Effective from admitted batch 2021-2022)

Course Objectives:

- To understand the basic concepts of organizational behaviour, its foundations and importance.
- To enable students to have a basic perspective of Motivation and Motivation theories.
- To acquaint the students about group behaviour in organizations, including communication, leadership conflicts and organizational change and how these are linked to and impact organizational performance.

Course Outcomes:

- Identifying fundamental aspects of organizational dynamics.
- Evaluate main theories of motivation and formulating suitable motivational strategies.
- Analyze the behaviour of individuals and groups in organizations.
- Understanding of Leadership theories and Leadership behaviour.
- Apply relevant theories, concepts to address important Organizational Behaviour questions.

SYLLABUS

Organisational Behaviour : Concept of Organisation - Concept of Organisational Behaviour - Nature of Organisational Behaviour - Role of Organisational behaviour - Disciplines contributing to Organisational Behaviour.

Motivation: Définition - Nature of Motivation - Role of Motivation - Theories of Motivation : Maslow's Need Hierarchy Theory, Herzberg's Motivation Hygiene Theory and Mc Gregor's Theory X and Theory Y.

Group Dynamics: Meaning - Concept of Group - Types of groups -Formal and Informal groups - Group development - Group cohesiveness and factors affecting group cohesiveness.

Leadership: Concept of Leadership - Difference between Leadership and Management - Importance of Leadership - Leadership styles: Autocratic leadership, Participative leadership and Free Rein leadership.

Communication: Meaning - Communication Process - Forms of communication: Oral, Written and Non- Verbal communication - Direction of communication : Downward, Upward and Horizontal communication.

Organisational conflicts: Concept of conflict - Reasons for conflict - Types of Conflict: Intrapersonal conflict, Interpersonal conflict, Intragroup conflict, Intergroup conflict, Interorganisational conflict - Conflict management.

Organisational Change: Nature - Factors in Organisational change -Planned change: Process of planned change - Resistance to change: Factors in résistance to change - Overcoming résistance to change.

Text Books :

1. L.M.Prasad: Organisational Beaviour, Sultan Chand & Sons, New Delhi -110002
2. K. Aswathappa: Organisational Behaviour, Himalaya Publishing House, New Delhi

Reference Books.

1. Stephen Robbins: Organisational Behaviour, Pearsons Education, New Delhi.

3. OPERATIONS RESEARCH

Course Objectives:

- Formulate a real world problem as a mathematical programming model.
- Provide knowledge of optimization techniques and approaches.
- Understand and study inventory problems.
- Know the network models.
- Put on knowledge in solving replacement problems and different queueing models

Course Outcomes:

- Learned to translate a real-world problem into a mathematical formulation.
- Formulate and Solve Transportation, Assignment and sequencing problems.
- Resolve inventory problems.
- Able to solve maximum flow and shortest path problems.
- Capable to solve replacement problems and analyze queueing models.

SYLLABUS

Introduction: Definitions of Operations Research; Phases of Operations Research; Types of Operations Research models; applications, merits and demerits of Operations Research.

Allocation: Linear Programming problem formulation; Basic assumptions; Graphical solution; Simplex method; Artificial variable technique; Two phase method; Big M method; Duality principle; Primal and Dual relation.

Transportation: Formulation; Solution methods; Unbalanced transportation problems - North west corner rule; Least cost entry method; Vogel's approximation method; Optimal solution; degeneracy.

Assignment: Formulation; Variations in Assignment problem; Travelling salesman problem.

Sequencing: Sequencing of - *n* jobs through two machines; *n* jobs through three machines; *n* jobs through *m* machines; 2 jobs through *m* machines.

Inventory Control: Introduction; Types of Inventory; Inventory costs; Deterministic models - Economic order quantity (EOQ) and Economic Production Quantity (EPQ) with and without shortages; Quantity discounts; P system; Q system; Inventory control Techniques.

Network Analysis: Network definitions; Time estimates in network analysis; Labeling using

Fulkerson’s rule; Forward pass computations; Backward pass computations; Project management using Critical Path Method(CPM) and Programme Evaluation and Review Technique(PERT).

Replacement: Introduction, Replacement of items that deteriorate with time - Value of money unchanging and changing, Replacement of items that fail completely.

Queueing models: Introduction; Single channel poisson arrivals; Exponential service times; Unrestricted queuewith infinite population and finite population models; Multi channel poisson arrivals; Exponential service times with infinite population and restricted queue.

Text Books:

1. Hamdy A Taha, "Operations Research- An Introduction" by TAHA , Prentice Hall, 2009.
2. F.S. Hiller, G.J. Liberman,B. Nag and P.Basu "Introduction To Operations Research,Mc Graw Hill Education(India), 2012.
3. S.D.Sharma, "Operations Research", Kedarnadh Ramnadh & Co.,2017

Reference Books:

1. R. Pannerselvam, "Operations Research", PHI..
2. Richard Bronson, Schaum’s Series," Operations Research", Mc Graw Hill
3. N.V.S.Raju, "Operations Research- Theory and Practice" BS publications.
4. V.K. Kapoor, "Operations Research" Sultan Chand & Sons.