Master of Technology

In

Civil Engineering (Water Resources)

Course Structure & Syllabus

Civil Engineering Department

National Institute of Technology Hamirpur

Hamirpur (HP) – 177005, India

Course Structure of M. Tech. Civil Engineering (Water Resources)

SEMESTER-I

Sr. No.	Course No.	Course Name	Teaching Schedule			Hours/ week	Credit
			L	T	P		
1	CE-611	Advanced Hydrology	4	0	0	4	4
2	CE-612	Advanced Hydraulics	4	0	0	4	4
3	CE-613	Advance Fluid Mechanics	4	0	0	4	4
4	CE-7MN	Programme Elective-I	4	0	0	4	4
5	CE-7MN	Programme Elective-II	4	0	0	4	4
6	CE-614	Computing in Hydraulics Lab	0	0	4	4	2
	Total		**20**	**0**	**4**	**24**	**22**

Programme Elective - I & II: List of Programme Electives is given in the Annexure.

SEMESTER-II

Sr. No.	Course No.	Course Name	Teaching Schedule			Hours/ week	Credit
			L	T	P		
1	CE-621	Water Resources Planning & Management	4	0	0	4	4
2	CE-622	Groundwater Engineering	4	0	0	4	4
3	CE-623	River Mechanics and Sediment Transport	4	0	0	4	4
4	CE-7MN	Programme Elective-III	4	0	0	4	4
5	CE-7MN	Programme Elective-IV	4	0	0	4	4
6	CE-624	Hydraulics Lab	0	0	4	4	2
	Total		**20**	**0**	**4**	**24**	**22**

Programme Elective – III & IV: List of Programme Electives is given in the Annexure.

SEMESTER-III

Sr. No.	Course No.	Course Name	Hours/week	Credit
1	CE-800	M.Tech. Dissertation	--	20
	Total			**20**

SEMESTER-IV

Sr. No.	Course No.	Course Name	Hours/week	Credit
1	CE-800	M.Tech. Dissertation	--	20
	Total		**--**	**20**

Total Credit of the Programme = 84

Annexure
List of Programme Electives

Programme Elective-I

CE-711	Hydro Power Engineering
CE-712	Introduction to Multiphase Flow in Porous Media
CE-713	Computation Techniques in Civil Engineering
CE-714	Earth Dams
CE-715	Environmental Impact Assessment

Programme Elective-II

CE-716	Watershed Management
CE-717	Transient Flow Analysis
CE-718	GIS and its Application in Civil Engineering
CE-719	Disputes and Arbitration in Engineering Projects

Programme Elective-III

CE-721	Open Channel Hydraulics
CE-722	Environmental Hydrology
CE-723	Disaster Management
CE-724	Finite Element Method

Programme Elective-IV

CE-725	Stochastic Hydrology
CE-726	River Engineering
CE-727	Optimization Methods
CE-728	Project Planning and Scheduling

Course Name: **Advanced Hydrology**
Course Code: **CE-611**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To introduce the phenomena of hydrology, watershed and different parts involved in hydrologic cycle.
- To introduce the fundamental concepts relevant to implementation of statistical and graphical techniques for proper understanding of the behavior of watershed.
- To enable the students to understand the factors that cause floods and snowmelts.
- The course aims to introduce students to advanced techniques of hydrological analysis that are of particular relevance to engineering and environmental design, planning and management.

Course Content

Introduction to Hydrology, Advanced study and analysis of the basic processes of hydrology of watershed including the theory, measurement and application of mathematical, statistical and graphical techniques associated with each of phenomena; Runoff hydrographs and unit Hydrographs for complex storms; synthetic and instantaneous hydrographs; Flood estimation and routing – Modern techniques; prediction of peak flow and snowmelt; yields from basins; Introduction to Hydrometeorology: Agro-climate; Climatic parameters; Instrumentation; Data recording and Trend analysis.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand advanced hydrological processes and techniques necessary for tackling engineering and environmental problems, such as predicting design floods and assessing the impact of human influences on watersheds.

CO2: Apply the concepts and techniques necessary for an understanding and runoff hydrographs and unit Hydrographs.

CO3: Apply advanced computer models for hydrological prediction.

Books and References

1. Hydrology: An Introduction by Brutsaert, Wilfred, Cambridge Univ. Press.
2. Physical Hydrology by Dingman, Prentice-Hall, Inc.
3. Applied Hydrology by Chow, V.T., D.R. Maidment, and L.W. Mays, McGraw-Hill Book Company.

Course Name: **Advanced Hydraulics**
Course Code: **CE-612**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge on the advanced areas of open-channel flow, and understand them in simple, lucid style.
- To provide students with basic skills and knowledge on hydraulics.
- To understand the behavior of rivers and their mechanism on practical environmental issues.

Course Content

Introduction to flow in open channels, Uniform flow and critical flow, Gradually varied flow – Theory and flow computations with special reference to compound sections, Flow profiles; Rapidly varied flow – Energy-depth relationships, Hydraulic Jump – prismatic and non-prismatic channel, Hydraulic jump as energy dissipators, Crested weirs, ogee spillway; Culvert hydraulics; Sluice gate flow; Spatially varied flow with increasing and decreasing discharge, Side weirs, Bottom racks; Channel design, Silt theories – Kennedy's and Lacey's, Erodible and non-erodible channels; Introduction to River Hydraulics, Sediment transport, River mechanics, river erosion, river training works, Dams – purpose, classification and site identification; Hydraulic models – Concept, Classification, Applications, & Modelling.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different types of flow from prismatic and non-prismatic channel
CO2: Apply principles and models related to problems of rivers.
CO3: It is expected that the students will be better equipped to address various engineering problems related to hydrology.

Books and References

1. Flow through Open Channel by Ranga Raju, K.G., Tata McGraw Hill, New Delhi.
2. Open Channel Hydraulics by Chow, V.T, McGraw Hill, New York.
3. Open Channel Flow by Hendersen, F.M., McGraw Hill, New York.
4. Open Channel Flow by Chaudhry, M. H., Prentice Hall of India.
5. River Behavior Management and Training, Vol. I & II by Central Board of Irrigation & Power (CBIP), New Delhi.
6. River processes: An Introduction to Alluvial dynamics by Andre Rober, ARNOLD, London.

Course Name: **Advance Fluid Mechanics**
Course Code: **CE-613**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To understand the concept of conservation equation for fluids and study the practical applications based on Navier stokes equations
- To introduce various types of flows and boundary conditions required to understand the behavior of fluids.
- To enable the students to understand concepts behind turbulence in fluid.

Course Content

Equation of fluid flow – Conservation of mass, conservation of momentum, stress and strain in fluid flow and their relations, conservation of energy, work done due to viscous stress, Navier stokes equations, Three dimensional continuity equation in Cartesian, cylindrical and spherical coordinates; Laminar flow of viscous incompressible fluids, Flow between parallel flat plates, Couette flow, plane Poiseuille flow, flow between two co-axial cylinders, flow between two concentric rotating cylinders, unsteady motion of flat plates; Boundary layer equation, Blasius solution, shear stress and boundary layer thickness, boundary layer on a surface with pressure gradient, momentum integral theorem for boundary layer, separation and its prevention by boundary layer suction; Concept of linearized stability of parallel viscous flow, transition to turbulent flow, Reynolds equation for turbulent flow, Reynolds stresses, Prandtl's mixing length theory, velocity profile, turbulent flow in pipes, turbulent boundary layer on flat plate; Inviscid flow, Elementary plane flow solutions, uniform stream, source or sink, vortex. Superposition of plane low solutions, flow over wedge and circular cylinder.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different fluid flow and application of Navier stokes equations.

CO2: Provide solutions related to problems for laminar flow in fluids and apply boundary conditions when required for studies related to hydrology.

CO3: Implement the concept of turbulence in water power poduction problems.

Books and References

1. Fluid Mechanics and Machinery by Ojha, Berndtsson and Chandramouli. Oxford University Press.
2. Fluid Mechanics by A.K. Jain. Khanna Publishers
3. Hydraulics and Fluid Mechanics by P.N.Modi and S.M.Seth. Standard Book House.
4. Wiley and Streeter by Fluid Mechanics F.M. White, Fluid Mechanics McGraw Hill Book Company.

Course Name: **Computing in Hydraulics Lab**

Course Code: **CE-614**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To provide basic knowledge on how to implement softwares for solving practical and research related problems.
- To provide skills for writing programme and using MATLAB, GIS/Arc-GIS, ANSYS and MIKE/MIKE-21C
- To enable and motivate the students perform analysis using softwares for various research works and projects.

List of Experiments

1. To understand fundamental concepts and basic tools of MATLAB Programming.
2. To study basic matrix operations in MATLAB.
3. To solve linear and differential equations using MATLAB.
4. To solve problems in water resources engineering using FFN/MLP, RBFNN and ANFIS.
5. To assign co-ordinates to raster data using geo-referencing in ArcGIS.
6. To create a shapefile and perform digitizing operations in ArcGIS.
7. To delineate a watershed using Digital Elevation Model in ArcGIS.
8. To understand basic tools and operations for analyzing computational fluid dynamics using ANSYS.
9. To analyze laminar flow through circular pipe in ANSYS.
10. To generate grids in MIKE/MIKE-21C.
11. To analyze Hydrodynamic and Sand Transport using MIKE/MIKE-21C.
12. To analyze Morphology & Reservoir Sedimentation using MIKE/MIKE-21C.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Perform MATLAB, GIS/Arc-GIS, ANSYS and MIKE/MIKE-21C effectively and efficiently.

CO2: Design and develop programming skills, study area maps.

CO3: Analyze various practical problems.

Course Name: **Water Resources Planning & Management**
Course Code: **CE-621**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the planning and management of water resources.
- To introduce the concepts of watershed management, integrated water resources management, environmental interaction of water resources and policies/framework related to water resources.
- To enable the students to understand the different components of water resources and their management.

Course Content

Historical profile on world water resources development; Global water resources, Hydrologic cycle, Watershed zoning, Interrelation of water resources with other natural resources and the environment, Water quantity and water budget, Water allocation and water scheduling; Watershed management, Rainfall-Runoff analysis, Floods measurement, frequency analysis, design of peak flood and routing, Reservoir operation and design; Water resources availability and demand, Water use sectors – Domestic, Industries and Agriculture, Sustainable water resources development, Integrated Water Resources Management (IWRM), Socio-economic aspects of water resources management, Rainwater Harvesting; Water resource planning – concept, preliminary study, feasibility study, detailed planning, Design of water distribution system, Irrigation scheduling and techniques; Hydrologic Processes – evaporation, transpiration and precipitation; Water quality parameters, Water pollution – causes, effects and measures; Global Efforts on Water conservation, Think Globally Act Locally on water resources, Local water organizations, National Water Policy, World water organizations - WUGs, WUAs, UN, WWP, WWC, etc. Environmental discourse on dam Construction.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different problems related to water resources planning, management and development.

CO2: Describe problems like water balance, rainfall-runoff analysis, water distribution networks, flood routing, irrigation scheduling, water pollution and other water related concerns.

CO3: Apply principles and guidelines to solve above mentioned problems.

Books and References

1. Global Water Partnership (GWP), Integrated Water Resources Management, Background Papers No. 4, Technical Advisory Committee (TAC).
2. Water Resources Systems Planning and Management, Vol. 51 by Jain, S.K. and V.P. Singh, Elsevier Science.
3. Hierarchical Analyses of Water Resources Systems: Modeling and Optimization of Largescale systems by Haimes, McGraw-Hill, New York.
4. Water Resources Systems Planning and Management by Loucks D.P. and van Beek E., UNESCO Publishing, The Netherlands.
5. Water Resources Systems Planning and Analysis by Loucks, D.P., J.R. Stedinger, and D.A. Haith, Prentice-Hall, N.J.
6. Hydrosystems Engineering and Management by Mays, L.W. and K. Tung, McGraw-Hill Inc., New York.

Course Name: **Groundwater Engineering**
Course Code: **CE-622**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the groundwater processes and their management.
- To introduce the fundamental concepts related to groundwater dynamics, environmental influence, numerical flow modelling, and techniques for managing groundwater resources.
- To enable the students to understand the processes and equations governing the behavior of groundwater.

Course Content

Introduction to groundwater resources, occurrence and movement, Aquifers and their characteristics/classification, Darcy's law, Dupit's assumptions; Flow nets, Groundwater tracers, Well hydraulics – steady/unsteady, uniform/radial flow to a well in a confined/unconfined/leaky aquifer, Well flow near aquifer boundaries/for special conditions; Groundwater levels, Quality of groundwater, Contaminant transport processes, Advection-dispersion equation, Treatment of contaminated groundwater, Climate change and groundwater; Introduction to Groundwater flow modelling, Governing equations, Finite difference solutions, Introduction to MODFLOW Software; Surface and sub-surface investigations, Artificial recharge, Saline water intrusion in aquifers - Ghyben-Herzberg relation, Remote sensing-based groundwater studies.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different groundwater movement, contamination and management problems.
CO2: Describe problems like groundwater movement in aquifers, contaminant transport, well hydraulics, modelling and management of groundwater.
CO3: Apply governing principles and equations to solve problems described in CO2
CO4: Assess the results obtained by solving above problems

Books and References

1. Groundwater Hydrology by Todd, D. K. and Mays, L. W., John Wiley & Sons, Inc.
2. Ground and Surface Water Hydrology by Mays, L. W., John Wiley & Sons, Inc.
3. Groundwater Modeling, in an Introduction to Water Quality Modelling by Mackay, R. & Riley, M., A. James, Wiley Publishers.
4. Hydrogeology: Principles and Practice by Hiscock, K. M. and Bense, V. F., Wiley-Blackwell.

Course Name: **River Mechanics and Sediment Transport**
Course Code: **CE-623**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the mechanics of river flow and transport of sediments.
- To introduce the fundamental concepts relevant to river mechanics, regime channels, sediment transport and sediment load.
- To enable the students to understand the processes that govern sediment transport and behavior of river flow.

Course Content

Introduction to river mechanics, Width-to-depth ratio of a river, Two-phase motion and its dimensionless variables, Mechanical properties of flow, Aggrading rivers, Degrading rivers, Meandering rivers, Bed Forms; Regime Channels, Channel roughness and resistance to flow, Tractive force method of stable channel design, Erosion, deposition, scour; Local scour problems; Introduction to sediment transport, Threshold of particle transport - critical velocity and critical shear stress concepts, Sediment movement in water, Principles of transport of solids in pipes, Principles of movement of sediment by waves tides and currents; Sediment Load, Bed load estimation - du Boys, Shields, Meyer Peter, Einstein bed load function, Yalin's formula, Paintals's stochastic approach, Suspended load - diffusion theory, Total sediment load by Kalinake, Latest models in sediment load assessment.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different problems pertaining to river mechanics and sediment transport.
CO2: Describe problems related to meandering of rivers, formation of river bed, resistance to flow, transport of sediments, load estimation on river bed and other related mechanisms.
CO3: Apply governing principles and formulas to solve problems described in CO2
CO4: Assess the results obtained by solving above problems

Books and References

1. Braided Rivers: Process, Deposits, Ecology and Management by Gregory H., Blackwell Publishing.
2. Sediment Transport-Theory and Practice by Yang, C. T., McGraw Hill Companies, Inc., New Delhi.
3. Rivers Form and Process in Alluvial Channels by Richards, K., Methuen, NY.
4. River Mechanics, Vol. I and II by Shen, H.W., Water Resources Publication, Fort Collins, CO. Water Resource Publications.

Course Name: **Hydraulics Lab**
Course Code: **CE-624**

Contact Hours/Week: **2P** Course Credits: **02**

Course Objectives

- To compare the results of analytical models introduced in lecture to the actual behavior of real fluid flows.
- To discuss and practice standard measurement techniques of fluid mechanics and their applications.
- To learn and practice writing technical reports and enable the students to work on small design projects.

List of Experiments

1. To verify Bernoulli's theorem experimentally,
2. To determine the coefficient of friction of pipes of different diameter,
3. To obtain surface profile on the total heads distribution of a forced vortex,
4. To measure flow using Rotameter and electrical analogy method for flow net,
5. To study the development of boundary layer on a flat plate,
6. To study the pressure distribution around sphere, aerofoil and cylinder placed in flowing fluid,
7. To study the use of various instruments for measuring parameters of hydro-meteorology,
8. To verify Darcy's law,
9. To determine saturated hydraulic conductivity of soil,
10. To study various infiltration capacity models using infiltrometer.

Note: *The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.*

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify and characterize flow patterns and regimes.
CO2: Demonstrate practical understanding of principles, equations and instruments of fluid flow related phenomena.
CO3: Discuss the differences among measurement techniques, their relevance and applications.
CO4: Demonstrate the ability to produce a working model through hands-on experience in fluid mechanics design.
CO5: Demonstrate the ability to write clear lab reports and understand ethical issues associated with decision making and professional conduct.

Course Name: **Hydro Power Engineering**
Course Code: **CE-711**
Course Type: **Programme Elective I**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To discover principles of operation and design of specific types of hydropower plants and installation of the necessary accessories for a specific location.
- To impart basic hydraulic solutions and proposals for hydraulic structures corresponds to hydropower and design of technological devices. Lessons learned
- To enable student to develop independent problem solving skill in the field of construction and design in hydroelectricity.

Course Content

Planning of Hydropower development; Hydropower potential; Operation of power plants for peak and base load; Characteristics of power market; Integration of various types of plants; Augmentation of power plants; Different types of hydro power plants; Small hydro power plants; Flow duration curve and its characteristics; Classification of modern turbines, efficiency, speed regulation, governors, coupling of turbines and generators. Types of power houses; Silting of reservoir, dead storage and useful life, rate of sedimentation, distribution of reservoir deposits, silt control. Surge tanks and hydraulic transients; Penstocks and pressure shafts; Intakes; Reservoir operation for hydropower generation in multipurpose projects; Basin scale hydropower development; Mathematical models for reservoir sizing and operation.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Describe the water flow through a power station.
CO2: Perform theoretical calculations on hydropower dams and spillway discharge.
CO3: Describe the principles of the electrical components and perform calculations of the parameters of the electrical system.
CO4: Discuss the environmental effects of hydropower installations.
CO5: Utilize the concepts in the course to analyse similar systems, which will acknowledge students to work together in a project related to the course contents.

Books and References

1. Hydro-electrical Engineering by Creager and Justin, John Wiley & Sons.
2. Water Power Engineering: Barrows, McGraw-Hill Book Company, New York
3. Water Power Development (Vol.-I and II) by Mosony L., Emil, Budapest, Pub. House of the Hungarian Academy of Sciences
4. Hydro –Electric and Pump Storage Plants by MG Jog, Wiley Eastern Limited
5. Micro Hydroelectric Power Stations by L. Monition, NPTI Publication.
6. Hydro Power Plant Familiarization by reena singh, NPTI Publication.
7. Water power engineering-The theory, investigation and development of water powers by Daniel, W. Mead, Member ASCE, Mcgraw-Hill Book Co.

Course Name: **Introduction to Multiphase Flow in Porous Media**
Course Code: **CE-712**
Course Type: **Programme Elective I**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To introduce the basic theory and computational techniques for modeling multiphase flow in subsurface porous media.
- To describe and investigate porous media, together with relevant single and multi-phase transport phenomena.
- To focused on the achievement of a clear and rigorous understanding of the fundamental properties, concepts and theories which are of importance in treating storage and multiphase fluid flow in sub-surface porous media.

Course Content

Introductory concepts of the physics and mathematics of multiphase flow, flow of immiscible fluids in porous media, pore level characterization, pore networks, invasion percolation in drainage and imbibition, capillary pressures and relative permeability, upscaling, Buckley-Leverett theory of two- and three-phase immiscible displacements.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Describe the physical nature and derive properties of porous media.
CO2: Describe flow dynamics in porous media.
CO3: Derive and manipulate equations governing saturated and unsaturated flows in porous media.
CO4: Construct conceptual and mathematical models that represent simplified scenarios of hydraulic behaviors of open channels and their causes.
CO5: Follow the technical literature on the subject, and carry-on independent research on related topics.

Books and References

1. Dynamics of Fluids in Porous Media by Bear, J., Dover Publications.
2. Multiphase flow in porous media by Adler, P. M., Springer.
3. Introduction to Percolation Theory by D. Stauffer, and A. Aharony, Taylor and Francis, London.
4. Applications of Percolation Theory by M. Sahimi, Taylor and Francis, London.

Course Name: **Computation Techniques in Civil Engineering**
Course Code: **CE-713**
Course Type: **Programme Elective I**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To provide an introduction to the basic principles, techniques, and applications of soft computing.
- To provide the mathematical background for carrying out the optimization associated with neural network learning
- To impart the skills of using soft computing in research problems

Course Content

Introduction of soft computing, soft computing vs. hard computing, various types of soft computing techniques, Fuzzy Computing, Neural Computing, Genetic Algorithms; Gene, Chromosome, Allele, Schemata Theory, genotype, phenotype, competition and selection – different types, Crossover – different techniques, elitism, mutation – different types, stopping criteria, Flow chart of GA. Evolutionary Algorithm: Simulated annealing, Evolutionary programming, Hill climbing. Fuzzy: Membership function, fuzzification, fuzzy operator, interference rules, defuzzification, exploration and exploitation; Particle Swarm Optimization, Ant colony optimization.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the type of algorithm for specific research problem.
CO2: Apply soft computing techniques in research problems
CO3: Interpret the results obtained from soft computing techniques.

Books and References

1. Neuro-Fuzzy and Soft Computing by J. S. R. Jang, C. T. Sun and E. Mizutani, Pearson Education.
2. Artificial Neural Network by Simon O. Haykin, PHI.
3. Applications of Soft Computing Techniques in Civil Engineering by S M. Yadav, Viva Books Private Limited

Course Name: **Earth Dams**
Course Code: **CE-714**
Course Type: **Programme Elective I**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about different types of dams and their basic design requirements.
- To introduce the analysis and concepts of seepage, stability and failure mechanism of dams.
- To enable the students to design different dam components.

Course Content

Classification of dams, Selection of site, Basic design requirements, Preliminary section, Seepage through dam section and its control, fundamentals of seepage flow, flow nets, Seepage through foundation, seepage control, filters, impervious core, drainage, foundation trench cutoff, upstream impervious blanket, horizontal drainage blanket, relief wells, drainage trenches, cut-off walls, downstream loading berm, Foundation treatment such as treatment of pervious, impervious and rock foundations, core contact treatment, grouting, foundation excavation. Stability analysis: critical slip surfaces, test conditions, strength parameters, pore pressures, stability analysis-method of slices, Bishops method, Morgenstern- price method, Janbu method. Construction of earth dams: construction equipment, procedures for pervious, semi-pervious, impervious and rock fill sections, construction supervision. Failures and damages of earth dams: nature of failures – piping, settlement cracks, slides, earthquake & miscellaneous damages.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: To know different types of dams, their basic design requirements and loads imposed.
CO2: To learn the analysis of dams
CO3: To assess the seepage through earth dams and seepage control measures
CO4: To proportion and design different types of dams
CO5: To perform stability analysis and foundation treatment in dams
CO6: To assess the construction aspects and design procedures of different dam components
CO7: To evaluate the causes and mechanism of failure of earth dams.

Books and References

1. Design of Earth Dams by A.L. Goldin, CRC Press.
2. Earth and Rockfill Dams: Principles for Design and Construction by Christian Kutzner, CRC Press.
3. Geotechnical Engineering of Dams by Robin Fell, Patrick MacGregor, David Stapledon, Graeme Bell, Mark Foster, CRC press.

Course Name: **Environmental Impact Assessment**
Course Code: **CE-715**
Course Type: **Programme Elective I**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To understand the concepts of ecology, sustainable development and EIA.
- To explore current EIA process in India.
- To acquire knowledge about various methods for conducting EIA, Environmental Legislation & Environmental Audit

Course Content

Environmental management- problems and strategies - Review of political, ecological and remedial actions - future strategies - multidisciplinary environmental strategies decision making and concepts of sustainable development. Concept of environmental audit - Life Cycle Analysis (LCA) - Environmental Management System - Introduction to ISO 14000, OSHA and Clean Development Mechanism (CDM) & Carbon credits. Introduction to various major natural disasters - flood, tropical cyclone, droughts, landslides, heat waves, earthquakes, fire hazards, tsunami etc., Factors for disaster - climate change, global rise in sea level, coastal erosion, environmental degradation, large dams, Legislative responsibilities of disaster management. Environmental legislation of Air, Water & Hazardous Waste - Environment Protection Act-1986 - Regulatory standards of CPCB / GPCB / BIS - EIA need and Notification - Environmental clearance. Introduction and Planning: Evolution of Environmental Impact Assessment - concepts of EIA - EIA methodologies screening and scoping - rapid and comprehensive EIA - General framework of EIA - characterization and site assessment - Environmental inventory - Prediction and assessment of impact - Impact assessment methodologies like adhoc method, checklist, overlap, network, model and index method. Decision methods of evaluation of alternatives - development of decision matrix - Public participation in environmental decision making - Objective of public participation -Technique for conflict management and dispute resolution- Verbal communication and Public Hearing in EIA studies - Status of EIA in India - Some typical case studies of EIA industrial and infrastructure projects.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO 1: Understand the importance & concepts of carrying out EIA.
CO 2: Acquire knowledge about current EIA process in India.
CO 3: Acquire knowledge about various methods & data requirements for conducting EIA.
CO 4: Analyze Impact's associated with various components of environment.
CO 5: Plan for mitigation of the impacts & monitor the mitigation measures.
CO 6: Acquire knowledge about Environmental Legislation & Environmental Audit.

Books and References

1. Environmental Impact Assessment by Larry W. Canter, Tata Mcgraw Hill Co, Singapore.
2. Environmental Impact Analysis by R. K. Jain, L. V. Urban & G. S. Stacey, Van Nostrand Reinhold Company, New York.
3. Environmental Impact Assessment by R. E. Munn, John Wiley & Sons, Toronto.
4. Environmental Engineering and Management by Suresh K. Dhameja, S. K. Kataria & Sons, Delhi.
5. Relevant MoEF Notifications and CPCB / GPCB Acts & Rules.

Course Name: **Watershed Management**
Course Code: **CE-716**
Course Type: **Programme Elective II**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To protect, conserve and improve the land of a watershed for more efficient and sustained production.
- To protect and enhance the water resources originating in the watershed.
- To moderate infiltration of rainwater and
- Provision for adequate supply of water for domestic, industrial and agricultural needs.

Course Content

Concept of watershed development, objectives of watershed development, need for watershed development in India, Integrated and multidisciplinary approach for watershed management. Characteristics of Watershed - size, shape, physiography, slope, climate, drainage, land use, vegetation, geology and soils, hydrology and hydrogeology, socio-economic characteristics, basic data on watersheds. Principles of erosion, Types of erosion, factors affecting erosion, effects of erosion on land fertility and land capability, estimation of soil loss due to erosion, Universal soil loss equation. Measures to Control Erosion, Contour techniques, ploughing, furrowing, trenching, bunding, terracing, gully control, rockfill dams, brushwood dam, Gabion. Rainwater Harvesting, catchment harvesting, harvesting structures, soil moisture conservation, check dams, artificial recharge, farm ponds, percolation tanks. Land use and Land capability classification, management of forest, agricultural, grassland and wild land. Reclamation of saline and alkaline soils. Role of Ecosystem, crop husbandry, soil enrichment, inter, mixed and strip cropping, cropping pattern, sustainable agriculture, bio-mass management, dry land agriculture, Silvi pasture, horticulture, social forestry and afforestation. Planning of watershed management activities, peoples participation, preparation of action plan, administrative requirements.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: To understand ecological and hydrological processes and concepts and apply them to watershed management actions such as harvesting, grazing, and restoration.

CO2: To will understand the history and policy that drives water management.

CO3: To apply assessment and classification tools to watersheds and their components to determine how management actions affect hydrologic responses.

Books and References:

1. Hydrology and the Management of Watersheds by Kenneth N. Brooks Peter F. Ffolliott Joseph A. Magner, John Wiley & Sons, Inc.
2. Integrated Watershed Management: Principles and Practice by Isobel W. Heathcote, John Wiley & Sons.
3. Watershed Management Guidebook by Kevin Drake and Michael Hogan, A Publication by Integrated Environmental Restoration Services, Inc.

Course Name: **Transient flow analysis**
Course Code: **CE-717**
Course Type: **Programme Elective II**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To implement comprehensive and effective flow control, achieving efficient water utilization, and maintaining rich fluvial environments.
- To solve a variety of problems on flow structures mainly in open channels, closed conduits and other related structures.

Course Content

Introduction to transient flow, surge movement in channels, two dimensional shallow water wave equation, numerical scheme for unsteady open channel flow; problems in handling mixed flow region; unsteady flow in closed-conduits and their solution; transients caused by pumps, methods of controlling transient in pipes; analysis of surge tanks; transient ground water flow.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the basic numerical scheme for unsteady flow in open channel and closed conduits.
CO2: Detect and analyze the flow transients through pumps and related hydraulic structures.
CO3: Equipped students to analyze pipe networks including pumps, valves, surge tanks, etc.

Books and References

1. Hydraulic Transients by Chaudhry, H., Applied hydraulic transients, Van Nostrand Reinhold, New York.
2. Hydraulic Transients by Streeter, V.L. and Wylie, E.B., McGraw Hill, New York.

Course Name: **GIS and its application in civil engineering**

Course Code: **CE-718**

Course Type : **Programme elective II**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- Understanding the need of CAD and GIS,
- Understanding map projection and working with coordinate systems,
- Understanding vector-based and raster-based data data analysis,
- Review of application areas of GIS in Civil Engineering, and
- Understanding basic principles of remote sensing.

Course Content

Introduction to Remote Sensing, data acquisition and processing, Electromagnetic Radiation (EMR) and its characteristics, Radiation principles, prosperities of solar radiant energy, atmospheric windows. Interaction in the atmosphere, nature of atmospheric interaction, atmospheric effects of visible, near infra-red thermal and microwave wavelengths, interaction at ground surface, interaction with soils and rocks, effects of soil moisture, organic matter, particles, size and texture, interaction with vegetation, spectral characteristics of individual leaf, vegetation canopies, effect of leaf pigments, radiation geometry. Introduction to Geographical Information Systems, Definition of GIS, Difference between GIS and CAD worlds, utility of GIS, various GIS packages and their salient features, essential components of a GIS, scanners and digitizers. Map projection and coordinate systems: Introduction, geographic Grid, Map projection, Coordinate systems. Vector data models and Analysis: vector data and its representation, topological data structure, non-topological vector data structure, TIN, Region, vector data editing and analysis. Raster data models and Analysis: acquiring and handling of raster data storage, function of raster based GIS data analysis. Engineering applications of GIS: applications of GIS in civil engineering.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the principles of remote sensing,

CO2: Understand the principles of geographic information systems,

CO3: Apply remote sensing and GIS to solving problems of Civil Engineering,

CO4: Maximize the efficiency of planning and spatial decision making, and

CO5: Integrate geographically referenced data and develop queries to generate usable information.

Books and References

1. Remote Sensing and Image Interpretation by T.M. Lillensand and R.W. Keifer, John Wiley and Sons.
2. Principles of Remote Sensing by P.J. Curren, Taylor & Francis.
3. Concept and Techniques of Geographical Information systems by C.P. Lo and Albert K.W.Yeung, Taylor & Francis.
4. Introduction to Geographical Information systems by Kang-tsung Chang, McGraw-Hill Higher Education.
5. Geographical Information systems- A Management Perspective by Stan Aromoff, Taylor & Francis.

Course Name: **Disputes and Arbitration in Engineering Projects**

Course Code: **CE-719**

Course Type: **Programme Elective II**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about avoidance of disputes and conflicts and wastage of time and Resources
- To enable students to be involved in the process of Conflict avoidance, management and Dispute resolution in construction projects.
- To understand range of dispute resolution techniques including Adjudication and Arbitration proceedings.
- To enable the student to understand conflict management and dispute resolution procedures including negotiation, mediation and conciliation, adjudication, arbitration and litigation.

Course Content

Project cost estimation, rate analysis, overhead charges, bidding models and bidding strategies. Owner's and contractor's estimate. Pre-qualification of bidders and enlistment of contractors. Tendering and contractual procedures, Indian Contract Act 1872, Definition of Contract and its applicability, Types of contracts, International contracts, FIDIC, Conditions and specifications of contract. Contract administration, Duties and responsibilities of parties Claims, compensation and disputes, Dispute resolution techniques, Arbitration and Conciliation Act 1996, Arbitration case studies, Negotiation

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the underlying causes of most conflicts and disputes and demonstrate knowledge and understanding the techniques used to avoid Conflicts and manage them.

CO2: Apply the basic principles of Dispute Resolution expeditiously.

CO3: Be involved in range of dispute resolution techniques including Adjudication and Arbitration proceedings.

CO4: Display knowledge about conflict management and dispute resolution procedures including negotiation, mediation and conciliation, adjudication, arbitration and litigation.

Books and References

1. A Guide to Quantity Surveyors, Engineers Architects and Builders (Vol I: Taking off quantities, Abstracting & Billing; Vol II: Analysis of Prices) by Kharb, K.S. Sushila Publications.
2. Construction Contracts by Keith Collier, Reston Publishing Company, Inc, Reston,Verginia.
3. Building and Engineering Contracts by Mrs. S.B. Patil, National Society Pune (India).
4. Construction Contracts - Law and Management by John Murdoch & Will Hughes, Spon Press, Taylor & Francis Group.
5. Law relating to Building and Engineering Contracts in India by Gajerai, G.T., Butterworths.
6. Govt of India, Central Public Works Department, "CPWD Works Manual 2003".
7. Govt of India, Central Public Works Department, "Analysis of Rates for Delhi (Vol 1 & 2)", and "Delhi Schedule of Rates".
8. Govt of India, Central Public Works Department, "CPWD 7/8: General Conditions of Contracts."
9. Govt of India, Military Engineer Services, "IAFW 2249: General Conditions of Contracts.

Course Name: **Open Channel Hydraulics**
Course Code: **CE-721**
Course Type: **Programme Elective III**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To develop a basic knowledge of open channel flow relationships by applying fluid properties.
- To gain proficiency in applying the basic principles of flow for ideal and real fluids in open channel flow problems.

Course Content

Fluid properties, Forces on submerged objects, Similitude and dimensional analysis, the energy equation for an ideal fluid. Introduction to flow in open channels- Velocity profiles, the energy equation applied to real fluids, Flow resistance, Computations for steady, uniform flow. Flow in channel sections with variable roughness, the momentum principle, Specific energy. Gradually varied flow in open channels, Determination of flow resistance in open channels, Classification of water-surface profiles, Local energy losses in natural channels, Water-surface profile computations. Discharge computations for rapidly varied flow, Rapidly varied flow at constrictions, Flow through culverts, Flow over weirs.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Summarize the differences between flow types and controlling features in open channel flows

CO2: Explain the terms of the open channel flow equations and explain the interactions among the terms.

CO3: Solve open channel flow problems through the selection and use of appropriate equations.

CO4: Able to design culverts.

Books and References

1. Basic Hydraulic Principles of Open-Channel Flow by Harvey E. Jobson and David C. Froehlich. U.S. Geological Survey, Books.
2. Open Channel Hydraulics by Chow, V.T, McGraw Hill, New York.
3. Open Channel Flow by Hendersen, F.M., McGraw Hill, New York.
4. Irrigation Engineering and Hydraulic Structures by S.K. Garg, Khanna Publishers.
5. Flow in Open Channels by K. Subramanya, Tata McGraw Hill.
6. Fluid Mechanics by V.L. Streeter and E.B. Wylie, McGraw Hill.
7. Fluid Mechanics by B.F. White, McGraw Hill, 1994.
8. Irrigation and Water Power Engineering by B.C. Punmia, Standard Publishers.
9. Fluid Mechanics with Engineering Applications by J. Frabzini, McGraw Hill.

Course Name: **Environmental Hydrology**
Course Code: **CE-722**
Course Type: **Programme Elective III**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To analyze and calculate the basic flows within the hydrological cycle in terms of the quantities of water and energy that move within various states.
- To integrate hydrological principles and river management objectives to negotiate and formulate water basin management contracts among opposing viewpoints.
- To enable students to describe the basic legal principles and conflict resolution alternatives that is relevant to river basin management.

Course Content

Basic concepts of environmental hydrology; water cycle, water balance and hydrological processes; environment and water; hydrology and climate, physical and biological interactions; water-related environmental problems; hydrological characteristics of India; drinking water, drinking water regulation and standards, water testing; forest hydrology, hydrological processes in forested area; urban hydrology, urbanization and hydrological processes, runoff process and flood; storm water storage and infiltration, reconstruction of urban water cycle; domestic, industrial, commercial, agriculture, and public water uses; water rights and development; water pollution and water quality policy, point and non-point source pollution and control, self-purification; sewage treatment; groundwater pollution, background and measurements of groundwater contamination, sources and fate of contaminants, organic solvents, phosphate and nitrate, remediation.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Effectively communicate hydrologic concepts and research.
CO2: Collect and analyze hydrologic data.
CO3: Understand a basic hydrologic or water resources research project that involves integrated problem solving.

Books and References

1. Environmental Hydrology by Ward A.D. and S.W. Trimble, Lewis Publishers, CRC Press.
2. Hydrology: An Environmental Approach by Watson and Burnett, CRC Press.
3. Soil and Water Management Systems by Schwab G. O, Delmar D. Fangmeier, Elliot, William J., John Wiley & Sons.

Course Name: **Disaster Management**
Course Code: **CE-723**
Course Type: **Programme Elective III**

Contact Hours/Week: **3L+1T** Course Credits: **04**

Course Objectives

- To impart knowledge about the disaster Management
- To introduce the fundamental concepts relevant to various aspect of disaster
- To enable the students to understand the factors that causes the disaster.
- To be able to assess risk and vulnerability for natural and manmade hazard

Course Content

Introduction to Natural & Man-made Disasters, Understanding Disasters, Geological and Mountain Area Disasters, Wind and Water Related Natural Disaster, Man Made Disasters, Technologies for Disaster Management role of information technology in Disaster Preparedness, Remote Sensing, GIS and GPS, Use and Application of Emerging Technologies, Application of Modern Technologies for the Emergency communication, Application and use of ICST for different disasters. Rehabilitation, Reconstruction and Recovery: Introduction and basic concept. Disaster Response and Management: Introduction to Response Essential Components, Stakeholders Co-ordination in Disaster Response, Human Behavior and Response Management and Relief Measures. Disaster Mitigation : meaning and concept, Disaster Mitigation Strategies, Emerging Trends in Disaster Mitigation, Mitigation management, Role of Team and Coordination.

Course Outcomes

After learning the course the students should be able to:

CO1: Understand disasters, disaster preparedness, role of IT, remote sensing, GIS and GPS,
CO2: Understand Rehabilitation, Reconstruction And Recovery,
CO3: Apply knowledge Disaster Response And Management, Risk Assessment and Vulnerability Analysis,
CO4: Understand Disaster Mitigation.

Books and References

1. Natural Hazards by Bryant Edwards, Cambridge University Press, U.K.
2. Disaster Management by Carter, W. Nick, Asian Development Bank, Manila.
3. Disaster Mitigation Experiences and Reflections by Sahni, Pardeep et.al. Prentice Hall of India, New Delhi.
4. Space Technology for Disaster management: A Remote Sensing & GIS Perspective by Roy, P.S., IIRS (NRSA) Dehradun.
5. Natural Disaster by Sharma, R.K. & Sharma, G., APH Publishing Corporation, New Delhi.
6. Disaster Management in the Hills by Singh Satendra, Concept Publishing Company, New Delhi.
7. Disaster Management through Panchayati Raj by Taori, K, Concept Publishing Company, New Delhi.

Course Name: **Finite Element Method**
Course Code: **CE-724**
Course Type: **Programme Elective III**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To learn basic principles of finite element analysis procedure.
- To learn the theory and characteristics of finite elements that represent engineering structures
- Learn to model complex geometry problems and solution techniques
- To learn and apply finite element solutions to Structural Engineering problem

Course Content

Approximate methods of Analysis, Introduction, Steps in finite element, Different approaches in FEM- Direct, Variational, Energy, Weighted residual,1-D FE Analysis- bar element, truss element, Beam element and Frame element, 2-D FE Analysis-CST element for plane stress and plane strain, Axis symmetry case,4-node rectangular element, langrangian interpolation function, 3-D FE Analysis- brick element, Assembling, iso-parametric formulations, Use of Symmetric and anti-symmetric condition.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the concepts various approaches in FEM.

CO2: Identify the application and characteristics of FEA elements such as bars, beams, plane and isoparametric elements, and 3-D element.

CO3: Apply FEM in different fields like, seepage proble, heat transfer etc.

CO4: Develop element level equation and generate global stiffness equation for the engineering problem

Books and References

1. Finite Element Analysis: Theory and Programming by C.S. Krishnamoorty, Tata McGraw-Hill Education.
2. Introduction to Finite Elements in Engineering, by T. R. Chandrupatla, A. D. Belegundu, Pearson Education Limited.
3. Fundamentals of Finite Element Analysis by D. V. Hutton, Tata McGraw-Hill Education.
4. Finite element methods, Vol I & Vol II by O.C. Zienkiewicz and R.L. Taylor, McGraw Hill.
5. Finite element procedures by K. J. Bathe, PHI Ltd.
6. Concepts and applications of finite element analysis by R.D. Cook, D.S. Malkus and M.E. Plesha, Third edition, John Wiley and Sons.

Course Name: **Stochastic Hydrology**
Course Code: **CE-725**
Course Type: **Programme Elective IV**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To introduce the concepts of probability theory and stochastic processes with applications in hydrologic analysis and design.
- To dealt with modeling of hydrologic time series with specific techniques for data generation and hydrologic forecasting.

Course Content

Review of fundamentals of probability and statistics, concepts of conditional probability, random variables and their transformations, concepts of moments and quantiles, commonly used probability distribution functions, principles of hypotheses testing; principles of Monte Carlo simulation and estimation theory; methods of maximum likelihood and least squares minimization; theory of random processes, estimation of linear static systems, random fields and stochastic-dynamic systems; Kalman filter and its applications in hydrologic real-time forecasting, stochastic characterizations and geostatistics; temporally and spatially variable subsurface flow analysis; theoretical approaches and applications of stochastic modeling to transport processes in heterogeneous porous media.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Learn important techniques of stochastic modeling.

CO2: Equipped students with methodologies of addressing uncertainties in hydrologic systems and forecasting.

CO3: Apply concepts of probability and statistics in water resources engineering research and practices.

Books and References:

1. Statistical Methods in Hydrology by Haan, C. T., Iowa State Univ. Press.
2. Stochastic Methods for Flow in Porous Media by Zhang, Dongxiao, Academic Press.
3. Random Functions and Hydrology by Bras, R.L. and Rodriguez-Iturbe, I., Dover Publications.
4. Stochastic Subsurface Hydrology by Gelhar, L.W., Prentice Hall.

Course Name: **River Engineering**
Course Code: **CE-726**
Course Type: **Programme Elective IV**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To enable students to apply fundamental concepts and techniques of hydraulics and hydrology in the analysis, design, and operation of water resources systems.
- To understand the mechanism of transport of various matters in rivers, and acquire the skills for evaluating the amounts of sediment transport and river bed evolution, and applying each element technology to practical problems.

Course Content

Introduction to river engineering, River classifications, thresholds in river morphology, hydraulic geometry, meander plan form, geomorphic analysis of river channel responses; Fundamentals of alluvial channel flows, uniform and unsteady cases, shear stress distribution, flow resistance in rivers; Physical properties of sediments, sediment movement in rivers, shear stress, Shields diagram, scouring around bridge piers and embankments, river bed forms; Analysis of river meanders, design of stable alluvial channels-regime concept, dimensional model studies for rivers, braided rivers, scaling and hierarchy in braided rivers, alternate bars, bed load transport in braided gravel-bed rivers; Stream bank erosion, bank protection, flow control structures, bank protection and river training along braided rivers.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify and justify appropriate engineering solutions.

CO2: Make observations of and investigate hypotheses about river processes and the impacts of river engineering alternatives.

CO3: Familiarize regional and global river systems and management.

Books and References

1. Fluvial Processes in River Engineering by Chang, H. H., John Wiley.
2. Fundamentals of Fluvial Geomorphology by Charlton, R., Taylor and Francis.
3. Braided Rivers: Process, Deposits, Ecology and Management by Gregory H., Blackwell Publishing.
4. Sediment Transport-Theory and Practice by Yang, C. T., McGraw Hill Companies, Inc., New Delhi.
5. Fluvial Forms and Processes by Knighton, D., Edward Arnold, Baltimore, MD.
6. Rivers Form and Process in Alluvial Channels by Richards, K., Methuen, NY.
7. River Mechanics, Vol. I and II by Shen, H.W., Water Resources Publication, Fort Collins, CO.
8. Applied fluvial geomorphology for river engineering management by Thorne, C R, Hey, R. D. and Newson, M. D. John Wiley & Sons.

Course Name: **Optimization Methods**
Course Code: **CE-727**
Course Type: **Programme Elective IV**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the optimization
- To impart knowledge about the multi-objective nature of Engineering Design
- To Apply optimization methods to solve the Engineering Design Problems

Course Content

Basics of engineering analysis and design, Need for optimal design, formulation of optimization problem, classical-simplex search, gradient search, Newton Raphson and global Optimization techniques-Introduction to GA, Constrained and Unconstrained optimization problems, Convex optimization, Sensitivity analysis, Numerical methods for nonlinear optimization problems.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understanding the basic concepts of classical optimization
CO2: Analysis of optimization algorithms
CO3: Applications of optimization in Civil Engineering

Books and References

1. Optimization for engineering design: Algorithms and examples by K. Deb, PHI Pvt Ltd.
2. Introduction to optimum design by J.S. Arora, McGraw Hill International editions.
3. Elements of structural optimization by R.T. Hafta and Z. Gurdal, Kluwer academic publishers.
4. Engineering Optimization theory and Practice by S. S. Rao, New Age International.

Course Name: **Project Planning and Scheduling**

Course Code: **CE-728**

Course Type : **Programme elective IV**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- Understanding the need of project planning,
- Understanding concept of bar-chart,
- Understanding planning and scheduling using critical path method,
- Understanding planning and scheduling using PERT and PDM, and
- Understanding scheduling of repetitive construction.

Course Content

Construction Planning: Objectives and functions, stages in construction, work breakdown structure, pre-tender stage planning, contract stage planning, methods of scheduling, bar charts, limitations of bar charts, milestone charts, preparation of material, equipment, labour, and finance schedule. Critical Path Method (CPM): Network techniques, element of a network, rules for developing networks, development logics, numbering events, time computations, activity floats, network updating. Resources profile, resources smoothing and resources leveling. Cost versus time, direct cost, indirect cost, total project cost, optimum duration, contracting network for cost optimization. Programme Evaluation and Review Technique (PERT): Probability concept in network, optimistic time, pessimistic time, most likely time, variance, standard deviation, slack, central limit theorem, probability of achieving completion time. Precedence Diagram Method (PDM): Precedence networks fundamentals, advantages, logic and precedence networks applications, PDM versus CPM. Line of Balancing (LOB) technique in the construction scheduling: Line of balance methods of scheduling repetitive construction.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Plan and schedule by bar-chart,

CO2: Understand the principles of critical path method,

CO3: Apply PERT and PDM to solving problems of Civil Engineering planning, and

CO4: Apply LOB to solving problems of repetitive construction planning

Books and References

1. Construction Project Management, Planning scheduling and controlling by Chitkara, K.K., Tata McGraw-Hill Education
2. Project Management with CPM and PERT, and precedence diagramming by Moder J.J. Philips, C.R. and Davis, E.W, Blitz Publishing Company.
3. CPM in Construction Management by Pilcher, R. “Project Cost Control in Construction” by Brien J.J., Mc. Graw Hill.