Curriculum and Syllabi

M. Tech. Degree Programme

Water Resources Engineering

DEPARTMENT OF CIVIL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY
CALICUT

DEPARTMENT OF CIVIL ENGINEERING

Curriculum for M. Tech. in Water Resources Engineering

First Semester

Sl No	Code	Title	L	T	P/S	C
1	CE6501	Advanced Fluid Mechanics	3	0	0	3
2	CE6502	Surface Water Hydrology and Hydrologic Systems	3	0	0	3
3	CE6503	Flow and Transport in Porous Media	3	0	0	3
4	CE6591	Computational Laboratory	0	0	3	2
5		Elective	3	0	0	3
6		Elective	3	0	0	3
7		Elective	3	0	0	3
TOTAL CREDITS = 11 (Core) + 9 (Electives) = 20						

Second Semester

Sl No	Code	Title	L	T	P/S	C
1	CE6511	Water Resources Systems Analysis and Design	3	0	0	3
2	CE6512	Remote Sensing and Its Applications in Water Resources Engg.	3	0	0	3
3	CE6513	Computational Hydraulics and Hydrology	3	0	0	3
4	CE6592	Term Project	0	0	2	1
5	CE6597	Seminar	0	0	2	1
6		Elective	3	0	0	3
7		Elective	3	0	0	3
8		Elective	3	0	0	3
TOTAL CREDITS = 11 (Core) + 9 (Electives) = 20						

Third Semester

Sl No	Code	Title	L	T	P/S	C
1	CE7598	Project Work	0	0	16	8
2		Elective (Optional)	3	0	0	(3)
TOTAL CREDITS = 8 (Core) + 0 or 3 (Elective) = 8 (11)						

Fourth Semester

Sl No	Code	Title	L	T	P/S	C
1	CE7599	Project	0	0	24	12
TOTAL CREDITS = 12						

Total Credits

Semester	L/T	P/S	Credits
Semester - I	18	3	20
Semester - II	18	4	20
Semester - III	0 (3)	16	8 (11)
Semester - IV	0	24	12
CUMULATIVE SUM OF CREDITS			60 (63)

LIST OF ELECTIVES

Sl No	Code	Title	Credits
1	CE6521	Statistical Methods in Hydrology	3
2	CE6522	Hydraulic Modelling	3
3	CE6523	Finite Element Method in Hydro Engineering	3
4	CE6524	Applied Hydraulic Modelling	3
5	CE6525	Hydrogeology and Groundwater Development	3
6	CE6531	Environmental Impact Assessment of Water Resources Projects	3
7	CE6532	Water Quality Modelling and Management	3
8	CE6533	Hydropower	3
9	CE6534	Watershed Management	3
10	CE6535	Environmental Hydraulics	3
11	CE6541	IT Applications in Water Resources Engineering And Management	3
12	CE6542	Urban Hydrology and Drainage	3
13	CE6543	Coastal Engineering and Coastal Zone Management	3
14	CE6544	Pollution Science and Engineering	3
15	CE6545	Geographical Information Systems and its Applications in Hydrology	3
16		Any other related subject offered in the Institute with the approval of the Course Coordinator	3

BRIEF SYLLABI

CE6501 Advanced Mechanics of Fluids

Prerequisite: Nil

L	T	P	C
3	0	0	3

Stress at a point and stress transformation. Acceleration of a fluid particle. System approach and control volume approach. Reynolds transport equation. Basic laws for finite systems and finite control volumes.Thermodynamic relations for finite systems and finite control volumes.Bernoulli's equation from the first law of thermodynamics. Differential forms of the basic laws.General incompressible viscous flow. Navier-Stokes equation. Potential flow .Mathematical considerations.Two dimensional sources and sinks. Axisymmetric 3D flows. 3D sources and sinks. 3D doublet.

Total Hours: 42

CE6502 Surface Water Hydrology and Hydrologic Systems

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Hydrologic cycle, Systems concept, Hydrologic system model, Hydrologic processes, Precipitation, Infiltration, Evaporation and Transpiration, Interception and Depression storage, Streamflow, Hydrograph analysis, Snowfall and snowmelt, Watershed concepts and modeling, Flood routing, Hydrologic simulation models, Design of drainage collection systems.

Total Hours : 42Hrs.

CE6503 Flow And Transport in Porous Media

Prerequisite: Nil

L	T	P	C
3	0	0	3

Groundwater and the hydrologic cycle.Occurrence and movement of groundwater.Darcy's law, aquifer and flow properties, steady state and transient flow, formulation of the governing equations, Ground water and well hydraulics, Groundwater modelling, Inverse modelling in groundwater. Flow in the unsaturated zone and flow in fractured formations, Saline water intrusion in coastal aquifers, Groundwater resource estimation, Quality of groundwater, Transport and transformation of contaminants in groundwater.

Total Hours: 42

CE6591 Computational Laboratory

Prerequisite: Nil

L	T	P	C
0	0	3	2

Flow and transport problems in pipelines, Flow and transport problems in open channels including rivers, Modelling lakes and reservoir, Groundwater flow and transport, Flow and transport in the vadose zone, Coastal circulation and sediment transport, Storm and sanitary sewer design, Flow routing in channels and rservoirs.

Total Hours: 42

CE6511 Water Resources Systems Analysis and Design

Prerequisite: Nil

L	T	P	C
3	0	0	3

Systems Techniques in Water Resources – optimization of functions of single and multiple variables using calculus.Linear programming.Dynamic Programming.Economic Considerations in Water Resources Systems. Benefit cost analysis. Multiobjective planning.Modelling of Reservoir Systems: (1) Deterministic Inflow (2) Random inflow .Linear Programming Applications – irrigation water allocation for single and multiple crops, reservoir operation for hydropower optimization. Dynamic Programming Applications – optimal crop water allocation, real-time reservoir operation for irrigation.

Total Hours: 42

CE 6512 Remote Sensing and Its Applications in Water Resources Engineering

L	T	P	C
3	0	0	3

Prerequisite: NIL

Remote sensing basics - Energy sources - EMR interactions with atmosphere and earth surface features - Remote sensing platforms – satellites - Image Interpretation - Microwave remote sensing – Radar Image interpretation- Platforms and sensors - Digital Image Processing – Storage formats - Geometric and Radiometric distortions – Enhancement techniques - Image classification – Accuracy assessment - Principal component transformation - Application of Multispectral images and Radar images - Case studies

Total Hours: 42 Hrs.

CE6513 Computational Hydraulics and Hydrology

Prerequisite: Nil

L	T	P	C
3	0	0	3

Classification of partial differential equationsLaplace Equation for irrotational flow, diffusion equation in groundwater flow, St.Venant's equations, modified Navier-Stokes equations, Numerical techniques to solve ordinary differential equations, Finite difference methods applied to steady state and transient flow problems, Basics of FEM, different formulations, finite difference in time domain, Solution of the advection-dispersion equation for solute transport by Eulerian and Lagrangian methods, Models for flow routing in reservoirs and channels. Models of coastal circulation and sediment transport.

Total Hours: 42

CE6521 Statistical Methods in Hydrology

Prerequisite: Nil

L	T	P	C
3	0	0	3

Random variables in hydrology and their probability distributions.Properties of hydrologic random. Moments and expectation of jointly distributed hydrologic random variables. Discrete Probability Distributions of Hydrologic Random Variables.Continuous Probability Distributions of Hydrologic Random Variables.Probability potting and frequency analysis of precipitation data and other hydrologic variables.Linear and nonlinear regression, transformation of nonlinear models.Multivariate analysis.Hydrologic time series.Stochastic hydrologic models.

Total Hours: 42

CE6522 HydraulicModelling

Prerequisite: Nil

L	T	P	C
3	0	0	3

Review of theoretical background required for hydraulic modeling, Development of physical models – dimensional analysis and principles of similitude, non-dimensional numbers employed in hydraulic modelling, tools and procedures, Modelling of open channel systems, closed conduit systems and urban drainage systems. Environmental modelling of open channel systems.,Modelling of estuaries, coastal processes, nearshore structures, and hydraulics structures.

Total Hours: 42

CE6523 Finite Element Method in Hydro Engineering

Prerequisite: Nil

L	T	P	C
3	0	0	3

Review of Basic Equations of Fluid Mechanics and Pipe Network Analysis.Linear finite element analysis of pipe networks.Computer algorithms for linear and non-linear analyses.One Dimensional Flow Analysis. Interpolation functions. Isoparametric formulation.Numerical integration.Potential Flow Analysis.Finite element solution of Navier- Stokes equations using stream function and vorticity formulation.Time Dependent Field Problems. One dimensional diffusion equation, analytical integration technique, time domain integration techniques – Euler method and improved Euler method. Introduction to typical CFD packages.

Total hours: 42

CE6524 Applied Hydraulic Modelling

Prerequisite: Nil

L	T	P	C
3	0	0	3

Conservation laws - mass, momentum and energy.Governing equations of fluid flow, initial and boundary conditions. Pipe flow - review of basic hydraulic principles design principles, analysis of distribution networks, Pump-pipeline and turbine-pipeline systems. Transients in pipelines, Open channel flow, critical flow and uniform flow concepts, flow in erodible channels, channel design, CBI & P method, tractive force method, Gradually varied flow compound channels, canal delivery problem, Rapidly varied flow design of spillways, Dam break analysis, Main canal and flow distribution control, decentralised control, canal automation, hardware and software components in automation systems.

Total Hours: 42

CE6525 Hydrogeology and Groundwater Development

Prerequisite: Nil

L	T	P	C
3	0	0	3

Groundwater and the hydrologic cycle, problems and perspectives, groundwater balance, status of groundwater development, major hydrogeologic formations in India.Basic concepts of groundwater management, Surface and subsurface investigations of groundwater, Types of wells, design and construction of open wells, Types of tube wells, multiple well system, radial wells and infiltration galleries, design of tube wells, Construction of bored and driven tube wells,Welldevelopment and well completion, Pumps used for lifting water, different types of selection of pumps, power requirement, efficiency and economics.

Total Hours: 42

CE6531 Environmental Impact Assessment of Water Resources Projects

Prerequisite: Nil

L	T	P	C
3	0	0	3

Concept of Environment and sustainable development.Environmental mpact assessment (EIA), Major features of the National Environmental Policy Act and the Council on Environmental Quality guidelines.Generalised EIA process flow chart of the UNEP. Evolution of EIA in India, Steps in EIA, Factors to be considered while assessing theimpacts of projects related to water, wastewater, solid wastes etc. Prediction and assessment of impacts on land and soil, groundwater, surface water, air, noise, biological, socio-economic and visual environments, Evaluation of alternatives.Preparing the EIA document/ report, Environmental impact statement (EIS).Case studies.

Total Hours: 42

CE6532 Water Quality Modelling and Management

Prerequisite: Nil

L	T	P	C
3	0	0	3

Water quality description, various characteristics of water, water quality criteria and standards, elements of reaction kinetics, spatial and temporal aspects of contaminant transport, transport mechanisms.Rivers and streams, convective diffusion equation and its applications.Estuary water quality models.Lakes and reservoirs quality models.Contaminant transport in unsaturated soil.Contaminant transport in groundwater.Water quality management.Management alternatives for water quality control.

Total Hours: 42

CE6533 Hydropower

Prerequisite: Nil

L	T	P	C
3	0	0	3

Different sources of energy. Fundamentals of water power engineering - classification of hydropower plants. Water power estimates Pondage and storage, Basic hydrology. Load curve and load factor, utilization factor, capacity factor, diversity factor. Firm power and secondary power.Prediction of load.Run of the river plants, pumped storage plants. Mini and micro hydel plants.Tidal power plants. General arrangement of a power house, types of power houses. Hydropower structures.Water Hammer.Surges and Surge Tanks.Turbines and Generators.Flood routing through reservoirs and channels.Dam breach analysis.Cost and value of water power.

Total Hours: 42

CE6534 Watershed Management

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Watershed - Definition and delineation, Watershed approach, Hydrologic cycle, Characteristics of watershed, Basic data on watersheds, Land use and water quality issues - Land use impacts on watersheds, Water quality monitoring, Erosion - Soil Erosion Modelling, Land management - Conservation measures, Water Harvesting, Ecosystem management.

Total Hours : 42Hrs.

CE6535 Environmental Hydraulics

Prerequisite: Nil

L	T	P	C
3	0	0	3

Fundamental relationships for flow and transport, Reynold's time-averaged mean flow and transport equations, model resolution, solution techniques, data requirements. Estimation of design flows.Models for rivers and streams - Completely mixed and Incompletely mixed systems. BOD and oxygen saturation, Streeter-Phelps equation, point and distributed sources.

Rivers and streams- stream hydro-geometry, low- flow analysis, dispersion and mixings, hydraulic methods for steady and unsteady flows and solution techniques, routing and water quality problems. Mixing in lakes and reservoirs, Transport and mixing in estuaries.Hydraulic analysis of various units in water treatment and wastewater treatment plants.Turbulent jets and plumes, ocean wastewater discharge systems.

Total Hours: 42

CE6541 IT Applications in Water Resources Engineering and Management

Prerequisite: Nil

L	T	P	C
3	0	0	3

Trends in information technology, artificial intelligence and knowledge, based expert systems, parallel processing, applications.Artificial neural network, genetic algorithms, fuzzy logic, applications.Satellite remote sensing, geographical information system, global positioning system, applications.Use of multimedia, web based engineering analysis and modelling, virtual reality, applications.

Total Hours: 42

CE6542Urban Hydrology and Drainage

L	T	P	C
3	0	0	3

Prerequisite: Nil

Stormwater runoff quantity and quality issues – Rainfall design – Design rainfall – Design storm hyetographs – Rainfall excess calculations – Calculation of runoff rates – Time of Concentration – Definition and calculation - Open-channel flow – Types – Overland flow model – Channel flow routing models - Drainage structures design – Storm sewer systems –Surface drainage - Urban flooding issues – Detention and Infiltration structures - Strom water quality - BMPs and LID concepts – Advantages – Computer models for storm water– Public domain packages

Total Hours: 42 Hrs.

CE6543 Coastal Engineering and Coastal Zone Management

Prerequisite: Nil

L	T	P	C
3	0	0	3

Coastal Engineering – coastal environment and coastal zone, problemsIntroduction to Wave Mechanics, classification of waves based on relative depth, Wave transformation, Breaking of waves. Finite Amplitude Waves, Stokes wave theory, Cnoidal wave theory, trochoidal wave theory, solitary wave theory, and stream function wave theory. Numerical wave theory.Tsunamis.Short term and long term wave statistics. Wind generated waves Causes of coastal erosion. Shore protection. Methods of shore protection. Wave structure interaction, Morison Equation, wave force on submarine pipelines.Coastal processes, application of mathematical models, Integrated coastal zone management, Coastal ecosystems including mangroves.

Prerequisite: Nil

CE6544 Pollution Science

Prerequisite: Nil

L	T	P	C
3	0	0	3

Module 1: (10 hours)
The environment as a continuum, Ecological concepts and natural resources.Physical and chemical characteristics of soil, water, and the atmosphere, biotic characteristics of the environment.Physical, chemical, and biological processes affecting fate and transport of contaminants in soil and water.Brief introduction to environmental toxicology, Pollution and mitigation of pollution of soil and land, and ground and surface waters. Introduction to global warming and climate change.Solid waste treatment and disposal, municipal wastewater treatment, land application of biosolids and animal wastes.Drinking water treatment and water security.Environmental Management.

Total Hours: 42

CE6545 Geographical Information Systems and Its Applications in Hydrology

L	T	P	C
3	0	0	3

Prerequisite: Nil

Maps basics – Map projections – GIS Definition – Components of GIS – Spatial and Non-spatial data – Database structures - Data Sources – Data models - Raster and Vector comparison – File Formats - Raster data analysis:– Vector data analysis – Map compilation - Modeling in GIS – Digital Elevation Models – SRTM – Flow routing algorithms – watershed and drainage delineation – Ground water application - 3D GIS – Area capacity computations

Total Hours: 42 Hrs.

CE6501 Advanced Mechanics of Fluids

Prerequisite: Nil
Total Hours: 42

L	T	P	C
3	0	0	3

Module1: (11 hours)
Stress at a point for a stationary or uniformly moving fluid, and for nonviscous flows. Stress transformation for viscous fluid motion. Acceleration of a fluid particle.Irrotational flow and its relation to viscosity. System approach and control volume approach. Reynolds transport equation. Basic laws for finite systems and finite control volumes.Conservation of mass. Linear momentum for control volumes fixed in inertial space. Moment of momentum for systems and inertial control volumes. Moment of momentum equation applied to pumps and turbines. Linear momentum and moment of momentum equations for noninertial control volumes.

Module 2:(11 hours)
Thermodynamic relations for finite systems and finite control volumes. System analysis and control volume analysis. Problems involving the first law of thermodynamics.Bernoulli's equation from the first law of thermodynamics. Differential forms of the basic laws – conservation of mass, Newton's laws, Euler equation, Bernoulli's equation. Newton's law for general flows.Index notation and Cauchy's formula.Gauss' theorem.Conservation of mass and momentum.First law of thermodynamics.

Module3:(10 hours)
General incompressible viscous flow – Navier-Stokes equation.Navier-Stokes equation for laminar incompressible flow. Parallel steady laminar flow problems – flow between infinite parallel plates, flow in pipes, flow in an annulus, Couette flow. Simplified Navier-Stokes equation for a very thin layer of flow.Dynamic similarity law from Navier Stokes equation. Turbulent flow – mean time averages for steady turbulent flow. Navier-Stokes equation for mean time average quantities.Apparent stress. Eddy viscosity.

Module 4:(10 hours)
Potential flow – Mathematical considerations.Circulation.Stokes' theorem.Circulation in irrotational flows.Velocity potential.Stream function and its relation with velocity field.Stream lines.Two dimensional sources and sinks.Simple vortex.Doublet.Superposition of 2D flows – sink plus vortex, flow about a cylinder without circulation.Rotating cylinder. Lift and drag for a cylinder with circulation. Axisymmetric 3D flows. Stokes' stream function.Relation between stream line, stream function, and velocity field. 3D sources and sinks. 3D doublet. Steady flow about a sphere.

References

1. Irving H. Shames, *Mechanics of Fluids*, McGraw-Hill, Inc.
2. S. W. Yuan, *Foundations of Fluid Mechanics*, Prentice-Hall of India.
3. William F. Hughes, and John A. Brighton, *Fluid Dynamics*, Schaum's Outline Series, McGraw-Hill.
4. I. G. Currie, *Fundamental Mechanics of Fluids*, CRC, Taylor and Francis.

CE6502 Surface Water Hydrology and Hydrologic Systems

Pre-requisite: Nil
Total Hours : 42Hrs.

L	T	P	C
3	0	0	3

Module 1: (12 hours)
Hydrologic cycle, Systems concept, Hydrologic system model, Hydrologic model classification.Hydrologic Processes – Continuity equations, Momentum Equations, Energy balance.Precipitation – Rainfall characteristics, Development of a design storm, Depth-Area Adjustment, Average areal rainfall, Estimating missing rainfall data, Gauge consistency.

Module 2: (10 hours)
Infiltration – Process, Factors affecting infiltration, Measurement, Modelling – Richard'sequation, Green Ampt model, Philip Two Term model, SCS model.Evaporation and Transpiration – Factors affecting evaporation, Measurement, Transpiration, Evapotranspiration, Penman equation.Interception and Depression storage – Factors affecting interception, stimation of interception, Factors affecting depression storage, Estimation of depression storage.

Module 3: (10 hours)
Streamflow – Sources of streamflow, Streamflow hydrograph, Excess rainfall and direct runoff.Hydrograph analysis – Baseflow separation, Estimation of initial abstraction, Separation of losses and rainfall excess, separation of losses using infiltration capacity curves, Introduction to unit hydrograph, Rainfall excess reciprocal method, S-hydrograph method.Snowfall and Snowmelt.

Module 4: (10 hours)
Watershed concepts and modeling.Flood routing – Hydrologic and hydraulic routing, Hydrologic river routing, Hydrologic reservoir routing, Governing equations for hydraulic river routing, Kinematic wave routing, Hydraulic river routing.Hydrologic simulation models – steps in watershed modeling, description of major hydrologic models, HEC flood hydrograph models. Design of Drainage collection systems

References

1. Chow, V.T., Maidment, D.R., and Mays, L.W., Applied Hydrology, McGraw Hill 1988.
2. Mccuen, R.H., Hydrologic Analysis and Design, Prentice Hall 2004
3. Singh, V.P., Elementary Hydrology, Prentice Hall 1991
4. Bedient, P.B., Huber, W.C., Vieux, B.E., Hydrology and Floodplain Analysis, Prentice Hall 2007

CE6503 Flow and Transport in Porous Media

Prerequisite: Nil
Total Hours: 42

L	T	P	C
3	0	0	3

Module 1:(10 hours)
Introduction – Groundwater and the hydrologic cycle, problems and perspectives. Occurrence and movement of groundwater: origin, age, distribution, types of aquifers. Darcy's law, hydraulic head and fluid potential, hydraulic conductivity and permeability, heterogeneity and anisotropy of hydraulic conductivity, porosity and void ratio, compressibility and effective stress, transmissivity and storativity, steady state and transient flow, formulation of the governing equations for groundwater movement, limitations of the Darcian approach.

Module 2:(12 hours)
Ground water and well hydraulics: steady and unsteady radial flows in aquifers (confined, unconfined and leaky), effect of well bore storage, multiple well systems, partially penetrating wells, bounded aquifers, characteristic well losses, specific capacity. Slug tests. Groundwater modelling, Inversemodelling in groundwater.

Module 3:(10 hours)

Introduction to flow in the unsaturated zone and flow in fractured formations.Artifical recharge of aquifers: concepts, hydraulics and methods. Saline water intrusion in coastal aquifers: occurrence, shape and structure of the interface, upconing, control of saline water intrusion. Groundwater budget.Groundwater resource estimation.

Module 4:(10 hours)
Introduction to groundwater contamination.Quality of groundwater: measures of quality, groundwater samples, physical, chemical and biological analyses, water quality criteria, and salinity. Transport and transformation of contaminants in groundwater: processes, formulation of the governing equations and initial and boundary conditions, solutions for simple cases.

References

1. R.A. Freeze and J. A. Cherry, *Groundwater*, Prentice Hall, Inc.
2. C. W. Fetter,*Applied Hydrogeology*, Merrill Publishing Co.
3. C. W. Fetter, *Contaminant Hydrogeology*, Prentice Hall, Inc.
4. P. A. Domenico and F. W. Schwartz, *Physical and Chemical Hydrogeology*, John Wiley & Sons, Inc.
5 F. W. Schwartz and H. Zhang, *Fundamentals of Groundwater*, John Wiley & Sons, Inc.
6 D. K. Todd, *Groundwater*, John Wiley & Sons, Inc.
7. A. K. Rastogi, *Numerical Groundwater Hydrology*, Penram International Publishing (India) Pvt. Ltd.
8. VedatBatu, *Applied Flow and Solute Transport Modeling in Aquifers*, Taylor and Franics.

CE6591 Computational Laboratory

Prerequisite: Nil
Total Hours: 42

L	T	P	C
0	0	3	2

To familiarise and give hands on training to students in formulating numericalmodels and using standard software for analyzing the following problems:

- Flow and transport problems in pipelines
- Flow and transport problems in open channels including rivers
- Modelling lakes and reservoirs
- Groundwater flow and transport
- Flow and transport in the vadose zone
- Coastal circulation and sediment transport
- Storm and sanitary sewer design
- Flow routing in channels and rservoirs.

CE6511 Water Resources Systems Analysis and Design

Prerequisite: Nil
Total Hours: 42

L	T	P	C
3	0	0	3

Module 1:(11 hours)
Concept of System and Systems Analysis - definition of a system, types of systems, systems approach, systems analysis. Systems Techniques in Water Resources – optimization of functions of single and multiple variables using calculus.Linear programming – problem formulation, simplex method, dual simplex method, sensitivity analysis, piecewise linearization. Dynamic Programming – characteristics of a DP problem, recursive relations, multiple state variables.

Module 2:(11 hours)
Economic Considerations in Water Resources Systems – general principles, discount factors, amortization, comparison of alternative plans, market demand and supply, aggregation of demand, water resources as a production process, conditions of optimality, benefit cost analysis – cost and benefit curves, cost and benefit estimation. Multiobjective Planning – noninferior solutions, weighting method and constraint method for plan formulation, plan selection, fuzzy multiobjective optimization.

Module 3:(10 hours)
Modelling of Reservoir Systems: (1) Deterministic Inflow – reservoir sizing, sequent peak analysis, reservoir capacity estimation using LP, storage yield function.Reservoir operation – standard operating policy, optimal operating policy using LP, standard policy using DP, simulation of reservoir operation for hydropower generation. (2) Random inflow – chance constrained LP, linear decision rule, deterministic equivalent of a chance constraint, reliability-based reservoir sizing, stochastic DP for reservoir operation – state variable discretization, inflow as a stochastic process, steady state operating policy, real-time operation.

Module 4:(10 hours)
Linear Programming Applications – irrigation water allocation for single and multiple crops, multireservoir system for irrigation planning, reliability capacity tradeoff for multicrop irrigation, reservoir operation for irrigation, reservoir operation for hydropower optimization. Dynamic Programming Applications – optimal crop water allocation, steady state reservoir operating policy for irrigation, real-time reservoir operation for irrigation.

REFERENCES
1. S. Vedula, and P. P. Mujumdar, *Water Resources Systems – Modelling Techniques and Analysis*, Tata McGraw-Hill Publishing Company Limited, New Delhi
2. D. P. Loucks, J. R. Stedinger, D. A. Haith, *Water Resources Systems Planning and Analysis*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.
3. L. W. Mays, and Y-K. Tung, *Hydrosystems Engineering and Management*, McGraw-Hill, Inc.
4. W. A. Hall, and J. A. Dracup, *Water Resources Systems Engineering*, Tata McGraw-Hill Publishing Company Limited, New Delhi
5. P. R. Bhave, *Water Resources Systems*, Narosa Publishing House, New Delhi.

CE 6512 Remote Sensing and Its Applications in Water Resources Engineering

Prerequisite: NIL

Total Hours: 42 Hrs.

L	T	P	C
3	0	0	3

Module I (11 hours)

Concepts and foundations of remote sensing- Energy sources and radiation principles- Energy interactions in the atmosphere – Energy interaction with earth surface features - Spectral reflectance of vegetation, soil and water - Atmospheric influence on spectral response patternsRemote sensing platforms – Sun synchronous systems- Geosynchronous systems-Across track and along track scanning systems – Types of sensor resolutions (Spatial, Spectral, Radiometric and Temporal resolution) – Mutispectral and thermal scanners – Characteristics of Remote sensing satellites and sensors (IRS, Landsat, SPOT, IKONOS)

Module II (11 hours)

Visual Image Interpretation -Standard False Colour Composites - Elements of visual image interpretation - Image interpretation strategies and interpretation keys Microwave remote sensing – Active and Passive remote sensing systems - Radar development – Side looking Radar System Operation - Synthetic Aperture Radar – Geometric characteristics of side-looking Radar imagery – Transmission characteristics of Radar signals – Radar Image interpretation- Platforms and sensors - ERS,JERS,RADARSAT missions – SAR interferometry - introduction

Module III (11 hours)

Digital Image Processing – Storage formats (BSQ, BIL, BIP) – Sources for Geometric and Radiometric distortions in images – Image rectification and restoration – Image histogram - Image enhancement - level slicing, contrast stretching, convolution filtering, Band ratioing – Merging multi-resolution images

Image classification – Supervised, Unsupervised and Hybrid classification – Supervised classification algorithms – Unsupervised classification algorithms - Accuracy assessment - Principal component transformation

Module IV (9 hours)

Application of Multispectral Remote sensing – landuse land cover mapping – Geologic and soil mapping – drainage delineation – Indices - NDVI, SAVI – Watershed managementApplication of Radar images – soil moisture estimation - case studies.

References

1. Thomas. M. Lillesand, Ralph. W. Kiefer and Jonathan W. Chipman, Remote Sensing and Image Interpretation , John Wiley and Sons, Inc., Fifth Edition, 2007
2. John A. Richards and XiupingJia, Remote Sensing Digital Image Analysis: An Introduction, Springer (Sge), Fourth Edition, 2008
3. Robert A. Schowengerdt, Remote Sensing: Models and Methods for Image Processing, Academic Press, Third Edition, 2009

CE6513 Computational Hydraulics and Hydrology

Prerequisite: Nil
Total Hours: 42

L	T	P	C
3	0	0	3

Module 1:(10 hours)
Eulerian and Lagrangian models. Classification of partial differential equations, Types of differential equations governing flow - Laplace Equation for irrotational flow, diffusion equation in groundwater flow, St.Venant's equations for one-dimensional flow in channels, modified Navier-Stokes equations for two-dimensional flow problems, shallow water wave equations, governing equations for contamination propagation in groundwater and surface water flows. Numerical techniques to solve ordinary differential equations, overview of solution techniques for partial differential equations - finite difference, finite element and finite volume methods.

Module 2:(11 hours)
Finite difference methods applied to steady state and transient flow problems – formulation and solution, examples. Similarity solutions in subsurface hydrology.

Module 3:(11 hours)Basics of FEM, different formulations, variational, weighted residual and Galerkin methods, appropriateness of these formulations to different problems, domain discretisation - different types of elements, integral equations for element matrices, derivations of boundary conditions, sources and sinks, finite difference in time domain, matrix equations, solution techniques, examples.

Module 4:(10 hours)
Solution of the advection-dispersion equation for solute transport by Eulerian and Lagrangian methods, examples.Models for flow routing in reservoirs and channels. Models of coastal circulation and sediment transport.

References

1. ChunmiaoZheng and Gordon. D. Bennett,*Applied Contaminant Transport Modeling*, Van NostrandReinhold.
2. VenTeChow,*Applied Hydrology*, Tata McGraw Hill Education Pvt. Ltd.
3. Christopher. G. Koutitas, *Mathematical Models in Coastal* Engineering, Pentech Press.
4. S. N. Ghosh, *Tidal Hydraulic Engineering*, Oxford and IBH Pub. Co. Pvt. Ltd.
5. S. C. Chapra, *Surface Water Quality Modeling*, McGraw Hill, Inc.
6 T. J. Chung, *Computational Fluid Dynamics*, Cambridge University Press.
7. A. K. Rastogi, *Numerical Groundwater Hydrology*, Penram International Publishing (India) Pvt. Ltd.
8. VedatBatu, *Applied Flow and Solute Transport Modeling in Aquifers*, Taylor and Franics.
9. C. A. Brebbia and A. J. Ferrante, *Computational Hydraulics*, Butterworths& Co. Pub.Ltd.
10. S. S. Rao, *The Finite Element Method in Engineering*, Elsevier.
11. J. N. Reddy and D. K. Garling, *Finite Element Method in Heat Transfer and Fluid Mechanics*, CRC Press.
12. O. C. Zienkiewicz and K. Morgan, *Finite Elements and Approximations*, John Wiley and Sons.

L	T	P	C

CE6521 Statistical Methods in Hydrology

3	0	0	3

Prerequisite: Nil
Total Hours: 42

Module 1:(10 hours)
Randomness of hydrologic variables – total probability and Bayes theorems.Random variables in hydrology.Univariate, bivariate, marginal and conditional distributions of hydrologic random variables. Independence. Derived and mixed distributions.Properties of hydrologic random variables – moments and expectation, moment generating functions.Measures of central tendency, dispersion, symmetry, and peakedness. Moments and expectation of jointly distributed hydrologic random variables, covariance, correlation coefficient, parameter estimation, Chebyshev inequality, law of large numbers.

Module 2:(12 hours)
Discrete Probability Distributions of Hydrologic Random Variables – hypergeometric distributions, Bernoulli process – binomial, geometric, and negative binomial distributions. Poisson process – Poisson, exponential, and gamma distribution, multinomial distribution. Continuous Probability Distributions of Hydrologic Random Variables – general and standard normal distributions, central limit theorem, constructing normal curves for hydrologic data, normal approximations of binomial, negative binomial, and Poisson distributions. Uniform, exponential, gamma, lognormal, extreme value, beta, and Pearson distributions.Chi-square, t-, and F-distributions.

Module 3:(10 hours)
Probability Plotting and Frequency Analysis – graphical and mathematical methods for construction of probability paper, probability plotting, analytical hydrologic frequency analysis, regional frequency analysis, frequency analysis of precipitation data and other hydrologic variables. Linear and nonlinear regression, transformation of nonlinear models.Correlation, correlation and regional analysis.Multivariate analysis, principal component analysis, univariate and multivariate data generation.

Module 4:(10 hours)
Hydrologic time series – definition, autocorrelation, spectral analysis, applications of autocorrelation and spectral density functions in hydrology. Stochastic hydrologic models – purely random stochastic models, first order Markov process, first order Markov process with periodicity, higher order autoregression models, multisite Markov model, Markov chain models of hydrologic processes.

References
1. C. T. Haan, *Statistical Methods in Hydrology*, Affiliated East-West Press and Iowa State University Press.
2. M. Shahin, H. J. L.vanOorschot, and S. J. de Lange, *Statistical Analysis in Water Resources Engineering*, A-A-Balkema, Rotterdam, Brookfield.
3. V. Yevjevich, *Probability and Statistics in Hydrology*, Water Resources Publications, Fort Collins, Colarado, USA.
4. V. Yevjevich, *Stochastic Processes in Hydrology*, Water Resources Publications, Fort Collins, Colarado, USA.
5. P. Jayarami Reddy, *A Text Book of Stochastic Hydrology*,Laxmi Publications, New Delhi.

CE6522 HydraulicModelling

Prerequisite: Nil
Total Hours: 42

L	T	P	C
3	0	0	3

Module 1:(10 hours)
Review of theoretical background required for hydraulic modelling – basic mathematics, hydraulics, and numerical techniques.

Module 2:(10 hours)
Development of physical models – dimensional analysis and principles of similitude, non-dimensional numbers employed in hydraulic modelling, tools and procedures.

Module 3: (11 hours)
Modelling of open channel systems, closed conduit systems and urban drainage systems.Environmental modelling of open channel systems.

Module 4:(11 hours)
Modelling of estuaries, coastal processes, nearshore structures, and hydraulics structures.

REFERENCES

1Pavel Novak, Vincent Guinot, Alan Jeffrey, and Dominic. E. Reeve, *Hydraulic Modelling – An Introduction*, Spon Press.
2. James. J. Sharp, *Hydraulic Modelling*, Butterworths.
3. Helmut Kobus and Gerrit Abraham, *Hydraulic Modelling*, Parey.
4. S. N. Ghosh, *Tidal Hydraulic Engineering*, Oxford and IBH Pub. Co. Pvt. Ltd.
5. VedatBatu, *Applied Flow and Solute Transport Modeling in Aquifers*, Taylor and Franics.
6. James. L. Martin and Steven. C. McCutcheon, *Hydrodynamics and Transport for Water Quality Modeling*, Lewis Pub..

CE6523 Finite Element Method in Hydro Engineering

Prerequisite: Nil
Total hours: 42

L	T	P	C
3	0	0	3

Module 1: (10 hours)
Review of Basic Equations of Fluid Mechanics and Pipe Network Analysis
Continuity, momentum, and energy equations, non-viscous fluid flow, irrotational flow, velocity potential, stream function, Bernoulli's equation, Navier-Stokes equation. Linear finite element analysis of pipe networks, total system of equations, boundary conditions, solution of system of equations, non-linear analysis of pipe networks, computer algorithms for linear and non-linear analyses.

Module 2: (12 hours)
One Dimensional Flow Analysis
Interpolation functions, C^m continuity. Governing differential equations, finite element formulations and solutions for (i) laminar flow through pipes, (ii) viscous flow on an inclined flat surface, (iii) thin film lubrication, and (iv) radial flow in an unconfined aquifer.
Isoparametric formulation.Numerical integration.Transformation of velocity, stress rates, and stiffness matrix.

Module 3:(10 hours)
Potential Flow Analysis
Euler's equation of motion, stream function formulation, potential function formulation, finite element solution of groundwater flow and flow around a cylinder.Finite element solution of Navier- Stokes equations using stream function and vorticity formulation.

Module 4:(10 hours)
Time Dependent Field Problems
One dimensional diffusion equation, analytical integration technique, time domain integration techniques – Euler method and improved Euler method. Introduction to typical CFD packages.

References

1. Brebbia, C. A., and A. J. Ferrante, Computational Hydraulics, Butterworths and Co. (Publishers) Ltd; 1983.
2. Chung, T. J., Computational Fluid Dynamics, Cambridge University Press, 2003
3. Vreugdentil, C. B., Computational Hydraulics, Springer Verlag, 1989.
4. Bickford, W. B., A First Course in the Finite Element Method, Irwin, 1994.
5. Segerlind, L. T., Applied Finite Element Analysis, John Wiley and Sons, 1984.
6. Reddy, J. N., An Introduction to the Finite Element Method, McGraw Hill Book Co; 1993.
7. Zienkiewicz, O. C.,and R.L. Taylor, The Finite Element Method, Vols. 1 and 2, McGraw Hill Book Co; 1989.
8. Rao, S.S., The Finite Element Method in Engineering, Elsevier, 2004.
9. Zienkiewicz, O. C.,and K. Morgan, Finite Elements and Approximation, John Wiley and Sons, 1983.
10. Zienkiewicz, O. C., R.L. Taylor, and J. Z. Zhu, The Finite Element Method – Its Basics and Fundamentals, Elsevier, 2005.
11. Baker, A. J., Finite Element Computational Fluid Mechanics, McGraw Hill Book Co; 1983.

CE6524 Applied Hydraulic Modelling

L	T	P	C
3	0	0	3

Prerequisite: Nil
Total Hours: 42
Module 1:(11 hours)
Conservation laws - mass, momentum and energy.Governing equations of fluid flow, initial and boundary conditions. Pipe flow - review of basic hydraulic principles of analysis and design of pipelines, losses in pipelines, pumping and gravity mains, economic analysis for pipe choice, pipe materials, specification for pipes, pipe appurtenances, design principles - internal pressures and external loads, analysis of distribution networks - Hardy Cross, equivalent pipe and Newton Raphson methods, computer applications in distribution network analysis, maintenance of distribution systems, methods of control and prevention of corrosion.

Module 2:(10 hours)
Pump-pipeline and turbine-pipeline systems. Transients in pipelines - causes, simple analysis by finite difference method and method of characteristics, transient control using surge tanks, air chambers and control valves

Module 3: (10 hours)
Open channel flow - canal network and hierarchy of canals, afflux and energy loss, critical flow and uniform flow concepts, flow in erodible channels, channel design - design of erodible and lined channels for clear and sediment-laden flows - CBI & P method, tractive force method, regime methods. Gradually varied flow - classification and computation of profiles, compound channels, canal delivery problem, channel networks, spatially varied flow.

Module 4: (11 hours)
Rapidly varied flow - hydraulic jump, analysis of surges, design of spillways, energy dissipators, and channel transitions. Dam break analysis.

Main canal and flow distribution control, decentralised control, canal automation - purpose and selection of
scheme, automation application, hardware and software components in automation systems, a typical automation system.

References

1VenTe Chow,*Open Channel Hydraulics*, McGraw Hill, Inc.
2. Richard. H. French, *Open Channel Hydraulics*, Water Resources Pub.
3. M. HanifChaudhry, *Open Channel Flow*, Springer.
4. Hubert Chanson, *TheHydraulics of Open Channel Flow – An Introduction*, Elsevier Butterworth-Heinemann.
5. E. B. Wylie and V. L. Streeter, *Fluid Transients*,McGraw Hill, Inc.
6. M. HanifChaudhry, *Applied Hydraulic Transients*, Van Nostrand Reinhold.
7. John. A. Fox, *Transient Flow in Pipes, Open Channels, and Sewers*, Ellis Horwood.
8. Thomas. M. Walski, *Analysis of Water Distribution Systems*, Van Nostrand Reinhold Co.
9. Bruce. E. Larock, Roland. W. Jeppson, and Gary. Z. Watters, *Hydraulics of Pipeline Systems*, CRC Press.
10. Thomas. M. Walski, Donald. V. Chase, Dragan. A. Savic, *Water Distribution Modeling*, Haestad Press.
11. CBIP, *Canal Automation*.
12. P. R. Bhave and R. Gupta, *Analysis of Water Distribution Networks*, Narosa Publishing House.

CE6525 Hydrogeology and Groundwater Development

Prerequisite: Nil
Total Hours: 42

L	T	P	C
3	0	0	3

Module 1:(10 hours)
Groundwater and the hydrologic cycle, problems and perspectives, arsenic and fluoride contamination of groundwater in India, groundwater balance, status of groundwater development – international and national scenarios, influence of physiography and climate on groundwater availability, major hydrogeologic formations in India.
Basic concepts of groundwater management, investigations and data collection, conjunctive use of surface and groundwaters, legal aspects of groundwater.

Module 2:(10 hours)
Basic geologic and hydrogeologic investigations including surface and subsurface investigations of groundwater, water divining/witching.
Types of wells, design and construction of open wells, open wells in alluvial and hard rock formations, failure of open wells, contamination and disinfection of open wells.

Module 3:(12 hours)
Types of tube wells, multiple well system, radial wells and infiltration galleries, design of tube wells - casing, bore size and depth, design of well screen and gravel pack, contamination of tube wells, failure of tube wells, rehabilitation of tube wells.
Construction of bored and driven tube wells – drilling equipment and methods, hand boring, mechanical percussion boring, direct and reverse circulation hydraulic rotary drilling, air rotary drilling, principles of rock drilling, drilling with foam, core drilling, calyx drilling, jetting. Installation of well screens and check for well alignment.
Well development and well completion.

Module 4:(10 hours)
Pumps used for lifting water - indigeneous water lifts, positive displacement pumps, centrifugal pumps, vertical turbine pumps, submersible pumps, propeller and mixed flow pumps, jet pumps, air lift pumps, selection of pumps, power requirement, efficiency and economics.

References
1. D. K. Todd, *Groundwater*, John Wiley & Sons, Inc.
2. F. W. Schwartz and H. Zhang, *Fundamentals of Groundwater*, John Wiley & Sons, Inc.
3 A. M. Michael and S. D. Khepar, *Water Well and Pump Engineering*, Tata McGraw Hill Publishing Co. Ltd.
4 A. M. Michael, *Irrigation Theory and Practice*, Vikas Publishing House Pvt. Ltd.
5. A. K. Rastogi, *Numerical Groundwater Hydrology*, Penram International Publishing (India) Pvt. Ltd.

CE6531 Environmental Impact Assessment of Water Resources Projects

Prerequisite: Nil
Total Hours: 42

L	T	P	C
3	0	0	3

Module 1:(10 hours)
Concept of Environment and sustainable development.Environmental impact assessment (EIA) – definitions, terminology and overview. Evolution of EIA – major features of the National Environmental Policy Act and the Council on Environmental Quality guidelines. Role of the USEPA in the environmental sector.Generalised EIA process flow chart of the UNEP. Evolution of EIA in India – major features of the EIA notification and its subsequent amendments, implementation of EIA in India. Legislation in India pertaining to various categories of waste.

Module 2:(10 hours)
Steps in EIA such as screening, initial environmental examination (IEE), scoping, public participation. Environmental baseline studies. Impact assessment methods such as adhoc methods, checklists, matrices, quantitative methods, environmental indices, networks, overlay etc. Factors to be considered while assessing theimpacts of projects related to water, wastewater, solid wastes etc.

Module 3: (10 hours)
Prediction and assessment of impacts on land and soil, groundwater, surface water, air, noise, biological, socio-economic and visual environments (including details of various tools that can be employed for prediction of impacts). Guidelines of the MoEF regarding EIA of specific projects.

Module 4:(12 hours)
Evaluation of alternatives.Preparing the EIA document/ report, Environmental impact statement (EIS).Strategic environmental impact assessment.Environmental monitoring, Environmental audit (EA).Case studies.

References

1. L. W. Canter, *Environmental Impact Assessment*, McGraw Hill, Inc.
2. Betty Bowers Marriot, *Environmental Impact Assessment: A Practical Guide*, McGraw Hill, Inc.
3. Barrow, C. J., *Environmental and Social Impact Assessment – An Introduction*, Edward Arnold.
4. Evan. K. Paleologos and Ian Lerche, *Environmental Risk Analysis*, McGraw Hill, Inc.
5 Peter Morris and RikiTherivel (eds.), *Methods of Environmental Impact Assessment*, Routledge.
6 UNEP, *Environmental Impact Assessment Training Resource Manual*.
7. EIA manuals of the Ministry of Environment and Forests (MoEF), Government of India.

CE6532 Water Quality Modelling and Management

Prerequisite: Nil
Total Hours: 42

L	T	P	C
3	0	0	3

Module 1: (10 Hours)
Water quality description, various characteristics of water, water quality criteria and standards, elements of reaction kinetics, spatial and temporal aspects of contaminant transport, transport mechanisms – advection, diffusion, dispersion.Equations of fluid flow and transport. Reynolds transport equations. Selection criteria for water quality models.Data requirements.

Module 2:(12 Hours)
Rivers and streams, convective diffusion equation and its applications.Turbulent dispersion and mixing – vertical and transverse mixing, longitudinal dispersion, turbulent dispersion in natural systems.Estuary water quality models, mixing in estuaries, basic mechanisms. Lakes and reservoirs quality models, stratification and heat transfer in lakes and reservoirs, mixing in lakes and reservoirs, water balances and multidimensional models of lakes and reservoirs.

Module 3: (10 Hours)
Contaminant transport in unsaturated soil.Solute transport model for conservative species.Solute transport in spatially variable soil.Contaminant transport in groundwater, advection, dispersion, one dimensional transport with linear adsorption, dual porosity models, numerical models, biodegradation reactions.

Module 4: (10 Hours)
Water quality management. Socio-economic aspects of water quality management, management alternatives – waste load allocation process, waste water disposal on land, regional treatment and transport, multiple point source waste reduction to meet water quality standards, flow augmentation, artificial in-stream aeration, lake quality management, groundwater quality management.

References
1. R. V. Thomann, and J. A. Mueller, *Principles of Surface Water Quality Modeling and Control*, Harper and Row, Publishers, New York.
2. S. C. Chapra, *Surface Water Quality Modeling*, The McGraw-Hill Companies, Inc.
3. J. L. Martin and S. C. McCutcheon, *Hydrodynamics and Transport for Water Quality Modeling*, Lewis Publishers, Boca Raton, London.
4. H. Chanson, *Environmental Hydraulics of Open Channel Flows*, Elsevier, Butterworth Heinemann
5. R. V. Thomann, *Systems Analysis and Water Quality Management*.
6. G. T. Orlob, *Mathematical Modeling of Water Quality*, John Wiley and Sons.
7. H. B. Fischer, E. J. List, R. C. Y. Koh, J. Imberger, N. H. Brooks, *Mixing in Inland and Coastal Waters*, Academic Press.
8. D. R. Maidment, *Handbook of Hydrology*, The McGraw-Hill Companies, Inc.

CE6533 Hydropower

Prerequisite: Nil
Total Hours: 42

L	T	P	C
3	0	0	3

Module1: (11 hours)
Different sources of energy. Hydropower – Place of hydropower in a power system, global and national status of hydropower development. Fundamentals of water power engineering - classification of hydropower plants. Water power estimates – Essentials of streamflow for water power studies. Pondage and storage, effect of pondage on plant capacity, benefits from storage. Basic hydrology - mass curve and flow duration curve, influence of reservoirs on flood flow. Load curve and load factor, utilization factor, capacity factor, diversity factor. Firm power and secondary power.Prediction of load.

Module2:(10 hours)
Run of the river plants, pumped storage plants. Mini and micro hydel plants.Tidal power plants. General arrangement of a power house, types of power houses.

Module 3: (10 hours)
Hydropower structures – intakes, forebay, gates and valves, penstocks, power canals and tunnels, anchor blocks.Joints. Bends and Manifolds. Water Hammer.Surges and Surge Tanks.

Module 4: (11 hours)
Turbines and Generators.Flood routing through reservoirs and channels.Dam breach analysis.Cost and value of water power.

References
1William. P. Creager and Joel De Witt Justin, *Hydroelectric Engineering Handbook*, John Wiley and Sons.
2. H. K. Barrows, *Water Power Engineering*, McGraw Hill Inc.
3. Emil Mosonyi, *Water Power Development*, Hungarian Academy of Sciences.
4. Guthrie Brown, *Hydroelectric Engineering Practice*, Blackie and Sons Ltd; London.
5. P. S. Nigam, *Handbook of Hydro Engineering*,Nem Chand and Bros., Roorkee.
6. M. M. Dandekar and K. N. Sharma, *Water Power Engineering*, Vikas Publishing House (P) Ltd.
7. SmailKhennas and Andrew Barnett, *Best Practices for Sustainable Development of Mini Hydropower in Developing Countries*, World Bank.
8. R. S. Varshney, *Hydro Power Structures*, Nem Chand and Bros., Roorkee.
9. R. S. Varshney, *Gates and Valves*, Nem Chand and Bros., Roorkee.
10. M. G. Jog, *Hydro–Electric and Pumped Storage Plants*, New Age International Publishers.
11. T. S. Bhatti, R. C. Bansal, and D. P. Kothari, *Small Hydro Power Systems*, DhanpatRai& Co. (P) Ltd.
12. UNIDO, *Small Hydro Power Series*.
13. Tong Jiandong, ZhengNaibo, Wang Xianhuan, Hai Jing, and Ding Huishen, *Mini Hydropower*, John Wiley and Sons.
14. Journals

CE6534 Watershed Management

Pre-requisite: Nil
Total Hours : 42Hrs.

L	T	P	C
3	0	0	3

Module 1: (12 hours)
Watershed - Definition and delineation, Watershed approach, Hydrologic cycle, Watershed components, Water budget, Watershed assessment, Watershed planning, Watershed as a management unit, Total maximum daily load.Characteristics of watershed - Size, Shape, Physiography, Slope, Climate, Drainage, Land use, Vegetation, Geology and Soils, Hydrology and hydrogeology, Socio-economic characteristics, Basicdataonwatersheds.

Module 2: (10 hours)
Land use and water quality issues - Land use impacts on watersheds, Residential activities, Municipal sources, Construction, Mining operations, Agriculture, Forestry practices, Recreation. Water quality monitoring – Temperature, pH, Dissolved Oxygen and Biological Oxygen demand, Nutrients, Pathogens, Turbidity, Biological monitoring methods, Species indicators, Biological integrity, Habitat index, Land use index, Water resource assessment, Water yield.

Module 3: (10 hours)
Erosion - Factors affecting erosion, Effects of erosion on land fertility and land capability, Soil Erosion Modelling, Erosivity and erodibility, Processes, USLE and modified/ revised USLE models for erosion processes. Land Management - Survey, Preparation and development, Soil and soil moisture conservation, Conservation measures, Ploughing, Furrowing, Trenching, Bunding, Terracing, Gully control, Rockfill dams, Brushwood dam, Gabion, Rain water management, Reclamation of saline soils.

Module 4: (10 hours)
Water Harvesting: Rainwater harvesting, Catchment harvesting, Harvesting structures, Soil moisture conservation, Check dams, Artificial recharge, Farm ponds, Percolation tanks. Ecosystem management: 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. Model watershed – Government and NGO Projects.

References

1. Randhir, T.O., Watershed Management Issues and Approaches, IWA 2007
2. Murty, J.V.S., Watershed management, New Age International 2009
3. Majumdar, D.K., Irrigation Water Management, Prentice Hall 2000

CE6535 Environmental Hydraulics

Prerequisite: Nil
Total Hours: 42

L	T	P	C
3	0	0	3

Module 1: (10 hours)
Fundamental relationships for flow and transport - general principles, instantaneous equation for fluid flow and transport, Reynold's time-averaged mean flow and transport equations, model resolution, solution techniques, data requirements. Measurement and analysis of flow - measurement of velocity and flow, tracer studies, estimating design flows.

Module 2: (11 hours)
Models for rivers and streams - Completely mixed systems - reaction kinetics, mass balance and steady state solution, particular solutions, feed-forward systems of reactors, feed-back systems of reactors, computer methods. Incompletely mixed systems - diffusion, distributed systems – steady and unsteady cases, steady state solutions, simple time variable solutions. BOD and oxygen saturation, Streeter-Phelps equation, point and distributed sources.

Module 3: (10 hours)
Rivers and streams- stream hydro-geometry, low- flow analysis, dispersion and mixings, flow model complexity and data requirements, estimating mixing in streams and rivers, hydraulic methods for steady and unsteady flows and solution techniques, routing and water quality problems. Mixing in lakes and reservoirs, water balance.Transport and mixing in estuaries.

Module 4: (11 hours)
Hydraulic analysis of various units in water treatment and wastewater treatment plants.Turbulent jets and plumes, ocean wastewater discharge systems.

REFERENCES
1. S. C. Chapra, *Surface Water Quality Modeling*, McGraw Hill, Inc.
2. James. L. Martin and Steven. C. McCutcheon, *Hydrodynamics and Transport for Water Quality Modeling*, Lewis Pub..
3. H. Chanson, *Environmental Hydraulics of Open Channel Flows*, Elsevier.
4. Larry D. Benfield, Joseph. F. Judkins, and A. David Parr, *Treatment Plant Hydraulics for Environmental Engineers*, Prentice Hall, Inc.
5. Hugo. B. Fischer, E. John List, Robert. C. Y. Koh, JorgImberger, and Norman. H. Brooks,*Mixing in Inland and Coastal Waters*, Academic Press.
6. Gerard Kiely, *Environmental Engineering*, Tata McGraw Hill Education Pvt. Ltd.
7. Frank. R. Spellman,*Handbook of Water and Wastewater Treatment Plant Operations*, CRC Press.
8. S. N. Ghosh, *Tidal Hydraulic Engineering,* Oxford and IBH Pub. Co. Pvt. Ltd.

CE6541 IT Applications in Water Resources Engineering and Management

Prerequisite: Nil
Total Hours: 42

L	T	P	C
3	0	0	3

Module 1: (11 hours)
Trends in information technology, artificial intelligence and knowledge based expert systems, parallel processing, applications.

Module 2:(11 hours)
Artificial neural network, genetic algorithms, fuzzy logic, applications.

Module 3: (10 hours)
Satellite remote sensing, geographical information system, global positioning system, applications.

Module 4:(11 hours)
Use of multimedia, web based engineering analysis and modelling, virtual reality, applications.

References
1A. Barr, P. R. Cohen, and E. A. Feigenbaum, *Artificial Intelligence – The Handbook*, Addison Wesley.
2. D. W. Patterson, *Introduction to Artificial Intelligence and Expert Systems*, Prentice Hall, Inc.
3. H. J. Zimmermann, *Fuzzy Set Theory and its Applications*, Springer.
4. Simon Haykin, *Neural Networks: A Comprehensive Foundation*, Prentice Hall, Inc.
5. David. E. Goldberg, *Genetic Algorithms in Search, Optimization, and Machine Learning*, Addison- Wesley.
6. Harry F. Jordan, *Fundamentals of Parallel Processing*, Prentice Hall, Inc.
7. Seyed. H. Roosta, *Parallel Processing and Parallel Algorithms: Theory and Computation*, Springer.
8. P. A. Burrough and R. A. McDonnell, *Principles of GIS*, Oxford University Press.
9. T. M. Lillesand, R. W. kiefer and J. W. Chipman, *Remote Sensing and Image Interpretation*, John Wiley & Sons.
10. Todd Knowlton, Karl Barksdale, E. Shane Turner, Stephen Collings, CEP Inc., *Programming BASICS: Using Microsoft Visual Basic, C++, HTML, and Java*, Course Technology.
11. M. B. Abbott, *Hydroinformatics – IT and the Aquatic Environment*, Avebury Technical.
12. Praveen Kumar, Mike Folk, Momcilo Markus and Jay C. Alameda, *Hydroinformatics: Data Integrative Approaches in Computation, Analysis, and Modeling*, CRC Press.
13. Howard Rheingold, *Virtual Reality: The Revolutionary Technology of Computer-Generated Artificial Worlds - and How It Promises to Transform Society*, Simon and Schuster.
14. Journals

CE6542 Urban Hydrology and Drainage

Prerequisite: NIL

Total Hours: 42 Hrs.

L	T	P	C
3	0	0	3

Module 1: (11 hours)

Introduction - Urbanization -Stormwater runoff quantity and quality issues – Rainfall design for urban catchments – Hydrologic and probabilistic description of rainfall – Design rainfall – Methods for construction of design storm hyetographs – Rainfall excess calculations – Computation of abstractions –Combined loss models. Calculation of runoff rates-basic concepts – elements of urban runoff hydrographs – Time of Concentration –Definition and calculation by various methods – Unit hydrograph method – NRCS method (TR-55)

Module 2: (11 hours)

Open-channel flow – Definitions - States of open channel flows – Open - Channel flow equations – Steady Gradually varied flow – Normal flow – Open channel rating curve – Overland flow – Kinematic wave model – overland flow on impervious and pervious surfaces – Channel flow routing– simplified and numerical models

Module 3: (10 hours)

Design of storm water drainage structures –Drainage design for street pavements – Storm sewer systems – Culverts – Surface drainage channels

Urban flooding and associated issues – Detention basins – Stage-discharge relationship - Detention basin design - Infiltration structures- Infiltration basins, Trenches

Module 4: (10 hours)

Strom water quality control - Concepts of BMPs and LID – Advantages – Computer models for urban storm water modelling – Public domain packages HEC-HMS, HEC-GeoHMS, EPA-SWMM.

References

1. Osman Akan, A and Robert J. Houghtalen, Urban Hydrology, Hydraulics, and Stormwater Quality: Engineering Applications and Computer Modeling, John Wiley and Sons, First edition, 2003
2. Ven T Chow, David Maidment, and Larry Mays, Applied hydrology, Tata Mc-graw Hill, First edition, 2011
3. National Engineering Handbook, Part 630, Natural Resources Conservation Service, United States Department of Agriculture
4. Storm Water Management Model Applications Manual, USEPA - EPA/600/R-09/077, July 2009
5. HEC-HMS Technical Reference Manual, US Army Corps of Engineers, CPD-74B, March 2000

CE6543 Coastal Engineering and Coastal Zone Management

Prerequisite: Nil
Total Hours: 42

L	T	P	C
3	0	0	3

Module 1:(11 hours)
Coastal Engineering – coastal environment and coastal zone, problems Water level fluctuations – tides, surgesand seiches.
Introduction to Wave Mechanics – wave generation, small amplitude wave theory - formulation and solution, wave celerity, length and period, classification of waves based on relative depth, orbital motions and pressure, standing waves, wave train and wave energy. Wave transformation – shoaling, reflection, refraction and diffraction, Breaking of waves.

Module 2:(11 hours)
Finite Amplitude Waves – higher order wave theories such as Stokes wave theory, Cnoidal wave theory, trochoidal wave theory, solitary wave theory, and stream function wave theory. Numerical wave theory.Wave interaction with currents.Regimes of application of different wave theories.Tsunamis.
Short term and long term wave statistics. Sea as a stationary random process - wave spectral density, mathematical spectrum models.
Wind generated waves – wave forecasting and wave hindcasting.

Module 3:(10 hours)
Causes of coastal erosion. Shore protection. Type of beaches.Methods of shore protection – structural and nonstructural methods.Wave structure interaction – Forces on shore structures due to breaking, broken and nonbreaking waves.Design of rubble mound structures.
Wave force on a circular (vertical, inclined and oscillating cylinder) - Morison Equation, wave force on submarine pipelines.

Module 4:(12 hours)
Coastal processes - long term and short term changes in the shoreline, cross shore and long shore currents, onshore-offshore movement of sediments, longshore transport, application of mathematical models, factors affecting equilibrium of beaches, coastal erosion and protection along the Kerala coast.
Integrated coastal zone management - resource planning and management, goals and purposes, sustainable use of resources, application of IT.Coastal ecosystems including mangroves.Mudbanks.Legislation in India pertaining to the coastal zone.

References

1. Arthur. T. Ippen, *Estuary and Coastline Hydrodynamics*, McGraw Hill, Inc.
2. Robert. M. Sorenson, *Basic Coastal Engineering*, John Wiley and Sons.
3. USACE, *Coastal Engineering Manual*.
4. T. Sarpkaya and M. Isaacson, *Mechanics of Wave Forces on Offshore Structures*, Van Nostrand.
5. Dominic Reeve, Andrew Chadwick, and Christopher Fleming, *Coastal Engineering*, Spon Press.
6. R. G. Dean and R. A. Dalrymple, *Coastal Processes with Engineering Applications*, Cambridge University Press.
7. J. W. Kamphius, *Introduction to Coastal Engineering and Management*, World Scientific.

CE6544 Pollution Science

Prerequisite: Nil
Total Hours: 42

L	T	P	C
3	0	0	3

Module 1: (10 hours)
Major environmental issues of the 21st century.The extent of global pollution.The environment as a continuum, Overview of environmental characterization.Ecological concepts and natural resources.Brief introduction to chemistry and microbiology in pollution science.Physical and chemical characteristics of soil, water, and the atmosphere, biotic characteristics of the environment.

Module 2:(12 hours)
Physical, chemical, and biological processes affecting fate and transport of contaminants in soil and water.Physical, chemical and biological contaminants.Environmental monitoring.Brief introduction to environmental toxicology.Statistics in pollution science.Risk assessment.Environmental laws and regulations in India.

Module 3: (10 hours)
Pollution and mitigation of pollution of soil and land, and ground and surface waters.Fertilizers, pesticides and sediments as a source of pollution.Atmospheric Pollution.Global atmospheric changes. Introduction to global warming and climate change.

Module 4:(10 hours)
Solid waste treatment and disposal, municipal wastewater treatment, land application of biosolids and animal wastes.Drinking water treatment and water security.Environmental Management.

References
1. I. L. Pepper, C. P. Gerba, and M. L. Brusseau, *Environmental and Pollution Science*, Academic Press.
2. G. M. Masters, and W.P. Ela, *Introduction to Environmental Engineering and Science*, Prentice Hall, Inc.
3. Gerard Kiely, *Environmental Engineering*, Tata McGraw Hill Education Pvt. Ltd.
4. Frank. R. Spellman, *Handbook of Water and Wastewater Treatment Plant Operations*, CRC Press.
5 J. Glynn Henry and Gary. W. Heinke, *Environmental Science and Engineering*, Pearson Education.
6 W. P. Cunningham and M. A. Cunningham, *Environmental Science – A Global Concern*, McGraw Hill, Inc.

CE6545 Geographical Information Systems and Its Applications in Hydrology

Prerequisite: NIL

Total Hours: 42 Hrs.

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Module 1: (11 hours)

Maps: Types – Characteristics – Coordinate systems – Map projections – Definition of GIS – Evolution – Components of GIS – Data: Spatial and Non-spatial – Spatial data: Point, Line, Polygon/Area and Surface – Non-spatial Data: Levels of measurement – Database structures.

Module 2: (11 hours)

Sources of data – Ground survey, Remote sensing data – Data input - Raster data model – Grid – Tessellations – Geometry of tessellations –– Data compression – Vector data model – Topology – Topological consistency – Vector data input– Raster Vs. Vector comparison – File Formats for Raster and Vector – Vector to Raster conversion- raster formats

Module 3: (11 hours)

Raster data analysis: Local, Neighborhood and regional operations – Map algebra – Vector data analysis: Non-topological analysis, Topological Analysis, Point-in-Polygon, Line-in-polygon, Polygon-in-polygon – Buffering –Voronoi diagrams– Map compilation.

Module 4: (9 hours)

Modeling in GIS – types – Digital Elevation Models: Generation, Representation, -SRTM– Single and Multi path flow routing algorithms – Sinks removal – Upslope contributing area - Automated watershed and drainage delineation –Ground water contours – Piezometric surface - 3D GIS – Reservoir area capacity computations

References

1. Lo, C. P. and A. K. W. Yeung, "Concepts and Techniques of Geographic Information Systems", Prentice Hall of India, 2002.
2. Zhilin Li, Qing Zhu, Chris Gold, Digital Terrain Modeling: Principles and Methodology, CRC Third edition 2004.
3. Michael N. Demers, Fundamentals of Geographic Information Systems, Wiley India Pvt. Ltd, Third Edition, 2008
4. Peter A Burrough, Rachael A Mc.Donnell, "Principles of GIS", Oxford University Press, 2000
5. Paul A. Longley, Michael Goodchild, David J. Maguire and David W. Rhind (Eds.),Geographical Information Systems: Principles, Techniques, Management and Applications, John Wiley & Sons, Second Edition, 2005