**M. Tech. Course Structure for Water Resources Engineering**
**(Modified for July 2011 Onwards)**

| | | |
|---|---|---|
| **SEMESTER-1** | | |
| **Course No.** | **Course Name** | **L – T – P – C** |
| CE 551 | Surface Water Hydrology | 3 – 0 – 0 – 6 |
| CE 553 | Advanced Hydraulic Engineering | 3 – 0 – 2 – 8 |
| CE 554 | Advanced Fluid Mechanics | 3 – 0 – 0 – 6 |
| CE xxx | Elective I | 3 – 0 – 0 – 6 |
| CE xxx | Elective II | 3 – 0 – 0 – 6 |
| | **Total Credits in First Semester** | 15– 0 – 2 – 32 |
| | **Contact Hours** | 17 |
| **SEMESTER-2** | | |
| CE 555 | Principles of Water Quality and EIA | 3 – 0 – 0 – 6 |
| CE 556 | Subsurface Hydrology | 3 – 0 – 0 – 6 |
| CE xxx | Elective III | 3 – 0 – 0 – 6 |
| CE xxx | Elective IV | 3 – 0 – 0 – 6 |
| CE xxx | Elective V | 3 – 0 – 0 – 6 |
| | **Total Credits in Second Semester** | 15– 0 – 0 – 30 |
| | **Contact Hours** | 15 |
| **SEMESTER-3** | | |
| CE 696 | Project and Dissertation | 0 – 0 – 24 – 24 |
| **SEMESTER-4** | | |
| CE 697 | Project and Dissertation | 0 – 0 – 24 – 24 |
| | | |
| | **Total Credits** | 30– 0 – 54 – 110 |

## LIST OF ELECTIVES

**Elective- I**

| | | |
|---|---|---|
| **CE 601** | Numerical Methods | 3-0-0-6 |
| **CE 602** | Optimization Methods | 3-0-0-6 |
| **CE xxx** | Some course on Probability or Statistics | 3-0-0-6 |

**Elective-II,III,IV,V**

| | | |
|---|---|---|
| **CE 552** | Water Resources Systems Analysis, planning & Management | 3-0-0-6 |
| **CE 557** | Environmental Hydrology | 2-0-2-6 |
| **CE 558** | Fuzzy Logic and Artificial Intelligence in Civil Engineering Applications | 3-0-0-6 |
| **CE 559** | Watershed Management and Remote Sensing Applications | 3-0-0-6 |
| **CE 560** | Computational Methods in Hydraulics and Environmental Engineering Applications | 3-0-0-6 |
| **CE 561** | Water Power Engineering | 3-0-0-6 |
| **CE 562** | Transient Flow Analysis | 3-0-0-6 |
| **CE 563** | Flow and Transport Processes in Fractured Media | 3-0-0-6 |
| **CE 564** | Stochastic Hydrology | 3-0-0-6 |
| **CE 565** | Introduction to Multiphase Flow in Porous Media | 3-0-0-6 |
| **CE 567** | Sediment Dynamics in Fluvial Systems | 2-0-2-6 |
| **CE 568** | Environmental Management of Water Resources | 3-0-0-6 |
| **CE 570** | River Engineering | 3-0-0-6 |
| **CE 572** | Pollution and Contaminant Flux in Water Environment | 3-0-0-6 |
| **CE 515** | Genetic Algorithms | 3-0-0-6 |

**Note: - Any one or two relevant courses from outside the Civil Engineering department can also be taken as Electives with the prior approval from Departmental Postgraduate Program Committee (DPPC)**

## DETAILS OF THE COURSE CURRICULUM

### *SEMESTER-1*

**CE 551 Surface Water Hydrology (3-0-0-6)**

*Pre-Requisite: Nil*

Basic concepts of hydrology; structure and composition of atmosphere, air mass, cold and warm fronts; atmospheric temperature and it variations; vapor pressure and relative humidity; evaporation and evapo-transpiration; types and forms of precipitation; measurement of precipitation and other atmospheric parameters; hydrograph analysis; probability, risk and uncertainty analysis for hydrologic and hydraulic design; flood routing – hydrologic and hydraulic routing - developing algorithms; hydrologic real time forecasting; urban hydrology; time series analysis.

***Texts:***

1. Chow, V.T., Maidment, D.R., Mays, L.W., **Applied Hydrology**, McGraw Hill, 1988.
2. Todd, D.K., **Ground Water Hydrology**, Wiley, New York, 1998.

***References:***

1. Mays, L.W., **Water Resources Engineering**, John Willey and Sons, US, 2001.
2. Haan, C. T., **Statistical Methods in Hydrology**, Iowa State University Press, 1977.
3. Maidment, D. R., **Handbook of Hydrology**, McGraw Hill, 1993.

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**CE 553 Advanced Hydraulic Engineering (3-0-2-8)**

*Pre-Requisite: Nil*

Open channel hydraulics, uniform flow, critical flow and GVF with special reference to compound channel, rapidly varied flow in prismatic and non-prismatic channel, channel design- erodible and non-erodible channels, silt theories, sediment transport; river mechanics, river erosion, river training works; dam engineering and related environmental issues; concept of hydraulic models.

***Laboratory:***

Experiment on Uniform flow, Hydraulic Jump, Unsteady Flow, Experiment on Two Phased Motion, Experiment on Weirs, Notch, Mouthpieces.

***Texts:***

1. Ranga Raju, K.G., **Flow through Open Channel**, Tata McGraw Hill, New Delhi,1996
2. Chow, V.T, **Open Channel Hydraulics**, McGraw Hill, New York, 1959
3. Hendersen, F.M., **Open Channel Flow**, McGraw Hill, New York, 1966.

***References:***


1. Chaudhry, M. H., **Open Channel Flow**, Prentice Hall of India, 1998.
2. **River Behavior Management and Training**, Vol. I & II, CBIP, New Delhi,1994
3. Andre Rober, **River processes: An Introduction to Alluvial dynamics**, ARNOLD, London, 1995.


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**CE 554 Advanced Fluid Mechanics (3-0-0-6)**

*Pre-Requisite: Nil*

Elementary introduction to Cartesian tensors and tensor operations, spatial (Eulerian) and material (Lagrangian) description of motion of deformable bodies, rotation and vorticity, strain rate tensor, time rate of change of volume and line integrals, Reynold's transport theorem, stress tensor, continuity and equilibrium equations, constitutive equations, derivation of Navier-Stoke's equation and its applications, introduction to laminar flow, Blasius equation, Karman momentum equation, description of turbulent flow, Kelvin-Helmholtz instability, mean flow equations, Prandtl's mixing length, turbulent Poiseuille flow, jets and wakes.

***Texts:***


1. Ligett, J. A., **Fluid Mechanics**, McGraw-Hill International Editions, 1994.
2. Batchelor, G. K., **An Introduction to Fluid Mechanics**, Cambridge University Press, London, 2005.
3. Shames, L. H., **Mechanics of Fluids**, McGraw-Hill, 1992


***References:***


1. Chatterjee, R.., **Mathematical Theory of Continuum Mechanics**, Narosa Publishing House, 1999.
2. Chung, T. J., **Continuum Mechanics**, Prentice Hall, 1988.


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## *SEMESTER-2*

**CE 555 Principles of Water Quality and EIA (2-0-2-6)**

Physical, chemical and biological quality of natural surface water and groundwater; Organic and inorganic pollutants in water and wastewater; water quality criteria for drinking, municipal, industrial, agricultural, recreational, wildlife and aquatic organisms; specific refractory substances in water and its impact on water usage; effluent discharge standards; environmental impact assessment (EIA), definitions and concepts, rationale and historical development of EIA, sustainable development, Initial environmental examination, environmental impact statement, environmental appraisal, environmental impact factors and

areas of consideration, measurement of environmental impact, organization, scope and methodologies of EIA, status of EIA in India.

***Texts:***

1. Larry W Canter, **Environmental Impact Assessment***,* 2nd Ed, McGraw-Hill, 1997.
2. Howard S. Peavy, Donald R. Rowe and George Tchobanoglous, **Environmental Engineering***,* McGraw-Hill International edition, 1985.

***References:***

1. G. Tchobanoglous and E. D. Schroeder, **Water Quality: Characteristics, Modeling and Modification**, Addison-Wesley Reading, MA, 1985.
2. Clair N Sawyer and Perry L McCarty, **Chemistry for Environmental Engineers**, McGraw-Hill., 1994.
3. **Standard Methods for the Examination of Water and Wastewater***,* APHA, AWWA, WPCF, Washington, D.C., 18th Ed, 1993.

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**CE 556 Subsurface Hydrology (3-0-0-6)**

*Pre-Requisite: CE554 Advanced Fluid Mechanics or equivalent*

The continuum approach to transport in subsurface hydrology; Darcy's law and its generalization; flow through saturated and unsaturated porous formations; well hydraulics, analysis of pumping test data, ground water recharge, water logging and salinity; infiltration and exfiltration from soils in absence and presence of a water table; modeling contaminant transport through porous media: dispersion, adsorption and decay, volatilization; applications of numerical models (GMS, FEFLOW, PMWIN, etc.) in hydrogeology; model conceptualization, discretization and calibration, initial and boundary conditions, use of Dirichlet and Neumann boundaries, modeling strategy, pitfalls and limitations; Management of groundwater resources, Development of management model, incorporation of simulation model with the optimization model; Applications: pollution control, mining and construction dewatering, saltwater intrusion, wetland protection from dewatering.

***Texts:***

1. Bear, J., **Dynamics of Fluids in porous Media**, Dover Publications, 1972.
2. Fetter, C.W., **Contaminant Hydrogeology**, Prentice Hall, 1999.

***References:***

1. Bear, J. and Verruijt, A., **Modeling Groundwater Flow and Pollution**, Reidel Publishing Company, 1990.
2. Fetter, C.W., **Applied Geohydrology**, Prentice Hall, 2001.

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## *ELECTIVE-I*

**CE 601 Numerical Methods (3-0-0-6)**

*Pre-requisites: Nil*

Linear equations and Eigen value problems, Accuracy of approximate calculations, Nonlinear equations, interpolation, differentiation and evaluation of single and multiple integrals, initial and boundary value problems by finite difference method, Newton's method, variation and weighted residual methods, introduction to finite element methods, fundamental of statistical distribution.

***Texts:***

1. J. B. Scarborough, **Numerical mathematical analysis**, Oxford & IBH Publishing CO Pvt., 2000
2. K. K. Jain, S. R. K Iyengar and R. K. Jain **Numerical methods-problem and solutions**, Wiley eastern limited, 2001

***References:***

1. R.W. Hamming, **Numerical methods for scientist and engineers**, McGraw Hill, 1998.
2. J. H. Mathews and K.D. Fink, **Numerical methods using MATLAB**, Pearson Education, 2004
3. A. J. Hayter, **Probability and statistics**, Duxbury, 2002.

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**CE 602 Optimization Methods (3-0-0-6)**

*Pre-requisites: Nil*

Basics of engineering analysis and design, need for optimal design, formulation of optimal design problems, basic difficulties associated with solution of optimal problems, classical optimization methods, necessary and sufficient optimality criteria for unconstrained and constrained problems, Kuhn-Tucker conditions, global optimality and convex analysis, linear optimal problems, Simplex method, Introduction to Karmarkar's algorithm; numerical methods for nonlinear unconstrained and constrained problems, sensitivity analysis, linear post optimal analysis, sensitivity analysis of discrete and distributed systems; introduction to variational methods of sensitivity analysis, shape sensitivity, introduction to integer programming, dynamic programming, stochastic programming and geometric programming, introduction to genetic algorithm and simulated annealing.

***Texts:***

1. K. Deb., **Optimization for Engineering Design: Algorithms and Examples**, PHI Pvt Ltd., 1998.

2. J. S. Arora, **Introduction to Optimum Design**, McGraw Hill International Edition, 1989.

***References:***

1. R. T. Hafta and Z. Gurdal., ***Elements of Structural Optimization***, Third Revised and Expanded Edition. Kluwer Academic Publishers 1996.

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## *ELECTIVES II, III, IV, & V*

### CE 552 Water Resources Systems Analysis, Planning & Management (3-0-0-6)

*Pre-Requisite: Nil*

Basic concepts of systems, need for systems approach in water resources, system design techniques, problem formulation; optimization techniques, LP, NLP, dynamic programming, genetic algorithm, sensitivity analysis, capacity expansion; reservoir operation problems, simulation, case studies; planning, role of a planner, National water policies, public involvement, social impact, economic analysis.

***Texts:***

1. Loucks, D.P., Stedinger, P.J.R., Haith, D.A., **Water Resources Systems Planning and Management**, Prentice Hall, New Jersey, 1987.

***References:***

1. Hall, K., A and Draoup, J.A., **Water Resources Systems Engineering**, Tata McGraw Hill, 1970.
2. Neil, G.S., **Water Resources Planning**, McGraw Hill, 1985.
3. National Water Policy, **Ministry of Water Resources**, Government of India, 1987.

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### CE 557 Environmental Hydrology (2-0-2-6)

*Pre-Requisite: Nil*

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.

***Laboratory:***
Experiments to complement/supplement theoretical topics including physico-chemical and bacteriological testing of surface and groundwater (major cations-anions, total coliform and faecal coliform, Fluoride, Arsenic, Phosphorous, Nitrogen)

***Text:***
1. Ward A.D. and S.W. Trimble, **Environmental Hydrology**. 2nd Edition. Lewis Publishers, CRC Press, 2004.

***References:***
1. Watson and Burnett, **Hydrology: An Environmental Approach**, CRC Press, 1995
2. Schwab G. O, Delmar D. Fangmeier, Elliot, William J., ***Soil and Water Management Systems.***, John Wiley & Sons, 1996

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**CE 558 Fuzzy Logic and Artificial Intelligence in Civil Engineering Applications (3-0-0-6)**

*Pre-Requisite: Nil*

Introduction - classification of artificial intelligence - Expert systems - artificial neural networks - basic concepts - uses in functional approximation and optimization – applications - case studies, Fuzzy logic - basic concepts - problem formulation using fuzzy logic – applications.

***Texts:***
1. **Fuzzy Logic Implementation and applications**, M.J. Patyra, Mlynek, Wiley Teubner, 1996.

***References:***
1. D.E. Rumelhart, and J.L. McClelland, **Parallel Distributed Processing**, Volume 1, MIT Press, England, 1986.

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**CE 559 Watershed Management and Remote Sensing Applications (3-0-0-6)**

*Pre-Requisite: Nil*

Principles of watershed management, soil water conservation practices, integrated planning, multi-disciplinary approach, management of agricultural lands - structural and non structural measures, forest and grass land management, erosion problems and controlling techniques, gully control, landslide and correction techniques, soil water plant relationships, watershed modeling.

Remote sensing: fundamentals – physics of remote sensing – electromagnetic radiation, interaction of ENR with atmosphere, earth surface, soils, water and vegetation. Data acquisition, photographic system and imaging systems, single vertical photographs, visible and near infrared imagery, photo interpretation, visual analysis, spectral properties of water, photogrammetry, stereoscopic viewing, application to water resources mapping, area assessment and watershed management – satellite data – geo-coding – GPS and GIS utilities – classification using imageries – applications in water resources and watershed management – case studies.

***Texts:***

1. Lillesand, K., **Remote Sensing and Image Interpretation**, John Wiley & Sons, 1979.
2. Tideman, E.M., **Watershed Management – Guidelines for Indian Conditions**, Omega Scientific Publishers, New Delhi, 1996.

***References:***

1. **FAO Watershed management and Field manual**, 13/1, 13/2,13/3,13/4,13/5 FAO, UN, Rome, 1988.
2. Reeves, R.G., **Manual of Remote Sensing, Volume I and II**, American Society of Photogrammetry, Falls Church, 1975.

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**CE 560 Computational Methods in Hydraulics and Environmental Engineering applications (3-0-0-6)**

*Pre-Requisite: CE 601 Numerical Methods*

Introduction – computing techniques –numerical methods - finite difference and finite element methods – applications in surface and ground water modeling, solute transport problems, pipe network analysis; artificial intelligence – applications.

***Texts:***

1. Pradip Niyogi, S. K. Chakrabarty, M. K. Laha, **Introduction to Computational Fluid Dynamics**, Pearson Education, 2005.
2. J. N. Reddy, **An Introduction to Finite Element Method**, Tata McGraw-Hill, New Delhi, 2003.

***References:***

1. Chow, V.T, Maidment, D.R., Mays.L.W., **Applied Hydrology**, McGraw Hill, 1988.

2. Chapra, S.C, Canale, R.P, **Numerical methods for Engineers**, McGraw Hill, 1990.
3. Segerlind, L.J., **Applied Finite Element Analysis**, John Wiley & Son, 1984.
4. Todd, D.K., **Ground Water Hydrology**, Wiley, 1993.

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**CE 561 Water Power Engineering (3-0-0-6)**

*Pre-Requisite: Nil*

Role of hydropower; turbines – different models – classifications – suitability of different types; components of hydro electric plants; power system terms and definitions; water power equations, demand curve, power economics, hydrologic analysis, power rule curve.

***Texts:***

1. P. Novak, A.I.B. Moffat, C. Nalluri, R.Narayanan, **Hydraulic Structure**, 2nd Ed E& FN SPON, 1997

***References:***

1. Chaudhry, H., **Applied hydraulic transients**, Van Nostrand Reinhold, New York, 1987.

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**CE 562 Transient flow analysis (3-0-0-6)**

*Pre-Requisite: CE 553 Advanced Hydraulic Engineering*

Introduction, 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.

***Texts:***

1. Chaudhry, H., **Hydraulic Transients**, Tata McGraw Hill, 1998.

***References:***

1. Chaudhry, H., **Applied hydraulic transients**, Van Nostrand Reinhold, New York, 1987.
2. Streeter, V.L. and Wylie, E.B., **Hydraulic Transients**, McGraw Hill, New York,1967

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**CE 563 Flow and Transport Processes in Fractured Media (3-0-0-6)**

*Pre-Requisites: Nil*

Fractured rock systems; hydrogeologic characterization methods; channeling; fracture network; point and non-point sources of pollutants; conservative and reactive solute transport; fracture flow and transport models.

***Texts:***

1. P. M. Adler, and J. F. Thovert, **Fractures and Fracture Networks**, Kluwer Academic Publishers, Dordrecht, 1999.
2. Committee on Fracture Characterization and Fluid Flow, **Rock Fractures and Fluid Flow: Contemporary Understanding and Applications**, National Academy Press, 1996.

***References:***

1. L. W. Gelhar, **Stochastic Subsurface Hydrology**, Prentice-Hall, Englewood- Cliffs, NJ, USA, 1993.
2. Committee on Source Removal of Contaminants in the Subsurface, **Contaminants in the Subsurface: Source Zone Assessment and Remediation**, National Academy Press, 2004.

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**CE 564 Stochastic Hydrology (3-0-0-6)**

*Pre-Requisite: Nil*

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.

***Texts:***

1. Haan, C. T., **Statistical Methods in Hydrology**, Iowa State Univ. Press, 1977.
2. Zhang, Dongxiao, **Stochastic Methods for Flow in Porous Media**, Academic Press, 2002.

***References:***

1. Bras, R.L. and Rodriguez-Iturbe, I., **Random Functions and Hydrology**, Dover Publications, 1994.
2. Gelhar, L.W., **Stochastic Subsurface Hydrology**, Prentice Hall, 1993.

**CE 565 Introduction to Multiphase Flow in Porous Media (3-0-0-6)**

*Pre-Requisite: Nil*

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.

***Texts:***

1. Bear, J., **Dynamics of Fluids in Porous Media**, Dover Publications, 1972.
2. Adler, P. M., **Multiphase flow in porous media**, Springer, 1995.

***References:***

1. D. Stauffer, and A. Aharony, **Introduction to Percolation Theory**, Taylor and Francis, London, 1992.
2. M. Sahimi, **Applications of Percolation Theory**, Taylor and Francis, London, 1994.

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**CE 567 Sediment Dynamics in Fluvial Systems (2-0-2-6)**

*Pre-Requisite: Nil*

Fluvial sediments; transportation and entrainment; physical & chemical characteristics; grain size distribution; chemical sedimentology; environmental chemistry of sediments; minerals in sediments, physical and chemical properties; texture, grain size, shape, sorting, surface features, packing, orientation, textural maturity, density, porosity, permeability, adsorption properties. Mechanical analysis of sediments: grade scale, frequency distribution and interpretation, laser particle distribution analysis, X-ray diffractometry, Atomic Absorption Spectrophotometry and scanning electron microscopy; shape analysis and their significance, graphical methods of representation of results; particulate nutrient and contaminant flux; modeling approach to sediment flux and concentration.

***Laboratory:***

Experiments to complement/ supplement theoretical topics including sediment studies in XRD, SEM, LPA and AAS

***Text:***

1. R.W Miller & R.L Donahue, **Soils in our Environment**, Prentice Hall, 2001
2. J.C. Griffiths, **Scientific methods in Analysis of Sediments**. McGraw Hill, 2002

***References:***

1. R. E. Grim, **Clay Mineralogy**, McGraw Hill, 1999
2. Chien, Calvin C.; Medina, Jr., Miguel A.; Pinder, George F.; Reible, Danny D.; Sleep, Brent, **Contaminated Ground Water and Sediment: Modeling for Management and Remediation**, CRC Press
3. Dominic M. DiToro, **Sediment Flux Modeling**, Wiley International, 2001

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**CE 568 Environmental Management (3-0 -0-6)**

Environmental management- principles, problems and strategies; Review of political, ecological and remedial actions; future strategies; multidisciplinary environmental strategies, the human, planning, decision-making and management dimensions; environmental impact assessment (EIA), definitions and concepts, rationale and historical development of EIA, sustainable development, Initial environmental examination, environmental impact statement, environmental appraisal, environmental impact factors and areas of consideration, measurement of environmental impact, organization, scope and methodologies of EIA, status of EIA in India; Environmental audit, definitions and concepts, environmental audit versus accounts audit, compliance audit, methodologies and regulations; introduction to ISO and ISO 14000; Life cycle assessment; Triple bottom line approach.

***Texts:***

1. L. W. Canter, **Environmental Impact Assessment**, 2nd Ed., McGraw-Hill, 1997.
2. N. P. Agarwal, **Environmental Reporting and Auditing**, Raj Pub., 2002.
3. P. Judith and G. Eduljee, **Environmental Impact Assessment for Waste Treatment and Disposal Facilities**, John Wiley & Sons, 1994.

***References:***

1. G. Burke, B. R. Singh and L. Theodore, **Handbook of Environmental Management and Technology**, 2nd Ed., John Wiley & Sons, 2000.
2. C. H. Eccleston, **Environment Impact Statements: A Comprehensive Guide to Project and Strategic Planning**, John Wiley & Sons, 2000.
3. J. G. Rau and D. C. Wooten, **Environmental Impact Analysis Handbook**, McGraw-Hill, 1980.
4. R. F. Fuggle and M. A. Rabie, **Environmental Management in South Africa**, Juta & Co. Ltd., 1991.
5. R. M. Harrison, **Pollution, Causes, Effects and Control**, 2nd Ed., Whitstable Lithop Ltd., 1990.
6. K. Whitelaw and Butterworth, **ISO 14001 : Environmental System Handbook**, 1997.

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**CE 570 River Engineering (3-0-0-6)**

*Pre-Requisite: Hydraulics and Hydraulic structures (CE 301)*

Overview of river engineering- river classifications, thresholds in river morphology, hydraulic geometry, meander plan form, geomorphic analysis of river channel responses; Hydraulics of river flow- fundamentals of alluvial channel flows, uniform and unsteady cases, shear stress distribution, flow resistance in rivers; Scouring and its criteria- physical properties of sediments, sediment movement in rivers, shear stress, Shields diagram, scouring around bridge piers and embankments, river bed forms; Regime rivers- 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; River training and stabilization- stream bank erosion, bank protection, flow control structures, bank protection and river training along braided rivers.

***Texts:***

1. Chang, H. H., **Fluvial Processes in River Engineering**, John Wiley, 1988.
2. Charlton, R., **Fundamentals of Fluvial Geomorphology**, Taylor and Francis, 2007.
3. Gregory H., **Braided Rivers: Process, Deposits, Ecology and Management** Blackwell Publishing, 2006.
4. Yang, C. T., **Sediment Transport-Theory and Practice**, McGraw Hill Companies, Inc., New Delhi, 1996.

***References:***

1. Knighton, D., **Fluvial Forms and Processes**. Edward Arnold, Baltimore, MD., 1984.
2. Richards, K., **Rivers Form and Process in Alluvial Channels**, Methuen, NY, 1982.
3. Shen, H.W., **River Mechanics, Vol. I and II***,* Water Resources Publication, Fort Collins, CO., 1971.
4. Thorne, C R, Hey, R. D. and Newson, M. D. **Applied fluvial geomorphology for river engineering management**, John Wiley & Sons, 1997.

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**CE 572 Pollution and Contaminant Flux in Water Environment (3-0-0-6)**

*Pre-Requisite: Nil*

Low temperature geochemical reactions in aqueous environments; chemical kinetics; thermodynamics, mixing and dilution, mineral stability, chemical composition of surface water, stable isotopes; contaminants and contaminants transport in near-surface environments; fluid –sediment interaction; fluid portioning; stability and mobility of groundwater contaminants; multi-phase systems; sampling considerations and overview of analytical techniques; flocculation, deposition and re-suspension of sediments; physico-chemical processes at sediment water interface; fate and effects of sediment bound

contaminants; partitioning of contaminants in water-sediment systems; bioassessment of sediment and water quality; effects of sediment mixing; parameterizing models for contaminated sediment transport; fluxes between trophic levels and through the water-sediment interface.

***Texts:***

1. H. E. Hemond and E. J. Fechner-Levy, **Chemical Fate & Transport in the Environment**, Academic Press, 2000.

***References:***

1. Alena Mudroch, M. A. Jose and M. Paul, **Manual of Physico-Chemical Analysis of Aquatic Sediments**, 2000.
2. J. J. Bonin and H. L. Golterman (Ed), **Fluxes between Trophic Levels and through the Water- Sediment Interface**, Kluwer Academic publishers, 1999.
3. Doeka Eisma, **Suspended Matter in the Aquatic Environments**, Springer-Verlag, Berlin, 1993.

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**CE 515 Genetic Algorithms (3-0-0-6)**

*Pre-Requisite: Nil*

Introduction to Evolutionary Computation: Biological and artificial evolution, evolutionary computation and AI, different historical branches of EC, a simple genetic algorithm. Search Operators: Crossover, mutation, crossover and mutation rates, Crossover for real-valued representations, mutation for real-valued representations, combinatorial GA, Selection Schemes: Fitness proportional selection and fitness scaling, ranking, tournament selection, selection pressure and its impact on evolutionary search. Theoretical Analysis of Evolutionary Algorithms: Schema theorems, convergence of the algorithms, computational time complexity of the algorithms, no free lunch theorem. Search Operators and Representations: Mixing different search operators, adaptive representations. Niching and Speciation: Fitness sharing, crowding and mating restriction. Constraint Handling: Common techniques, penalty methods, repair methods, Deb's penalty parameter method. Multi-objective evolutionary optimization: Pareto optimality, multi-objective evolutionary algorithms: MOGA, NSGA-II, etc. Applications of GA in engineering problems, job-shop scheduling and routing problems

***Texts:***

1. D. E. Goldberg, **Genetic algorithms in search, optimization, and machine learning**, Pearson Education Inc, 2002.
2. K. Deb, **Multi-Objective Optimization Using Evolutionary Algorithms**, Wiley and Sons, 2009.
3. M. Mitchell, **An introduction to genetic algorithms**, MIT Press, 1996.
4. L. D. Davis, **Evolutionary algorithms**, Springer-Verlag, 1999.
5. D. N. Kumar and K. S. Raju, **Multicriterion analysis in engineering and management**, Phi Learning Pvt. Ltd., New Delhi, India, 2010.