**SYLLABUS**

**FOR**

**TWO-YEAR M. TECH. PROGRAMME**

**IN**

**WATER RESOURCE ENGINEERING**



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| **NAAC – A Grade** |

**DEPARTMENT OF CIVIL ENGINEERING**

**COLLEGE OF ENGINEERING & TECHNOLOGY**

**(An Autonomous and Constituent College of BPUT, Odisha)**

**Techno Campus, Mahalaxmi Vihar, Ghatikia,**

**Bhubaneswar-751029, Odisha, INDIA**

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**COURSE: M. Tech. (CE - Water Resources Engineering), Duration: 2 years (Four Semesters)**

**Abbreviations Used: U= UG, I= Integrated, P= PG**

**PC= Professional Core PE= Professional Elective OE= Open Elective**

**LC= Lab Course MC= Mandatory Course AC= Audit Course**

**L= Lectures P= Practical/Laboratory IA\*= Internal Assessment**

**T= Tutorial PA= Practical Assessment EA=End-Semester Assessment**

**\*Internal Assessment Max. Mark (30 marks) consists of Mid Semester (20 marks) and Quiz+Assignment (10 marks)**

**Subject Code Format:**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| **Prog (U/I/P)** | **Type (PC/PE/OE/LC/MC/AC)** | | **Department (CE/EE/IE/ME/…)** | | **Semester (1/2/…/0)** | **Serial No. (1/2/3/…/99)** | |

**1st SEMESTER**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Subject**  **Type** | **Subject Code** | **Subject**  **Name** | **Teaching Hours** | | | **Credit** | **Maximum Marks** | | | |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Core 1 | PPCCE105 | Advanced Fluid Mechanics (CE) | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 2 | Core 2 | PPCCE106 | Advanced Hydrology | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 3 | Professional Elective 1  (Any One) | PPECE111 | Water Resources System Planning and Management | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPECE112 | Design of Hydraulic Structure and Hydropower Engineering |
| PPECE113 | Modelling, Simulation and Optimization |
| 4 | Professional Elective 2  (Any One) | PPECE104 | Advanced Numerical Methods | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPECE114 | Application of Soft Computing Techniques |
| PPECE115 | Advanced Irrigation Engg. & Drainage |
| 5 | Mandatory | PMCMH101 | Research Methodology & IPR | 2 | 0 | 0 | 2 | 30 | 70 | - | 100 |
| 6 | Lab 1 | PLCCE105 | Hydraulic Engineering Lab | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| 7 | Lab 2 | PLCCE106 | Software Lab | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| **Total** | | | | **14** | **0** | **8** | **18** | **150** | **350** | **200** | **700** |
| 8 | Audit 1 | Any one subject from Appendix-I | | | | | | | | | 100 |
| **Grand Total** | | | | | | | | | | | **800** |

**2nd SEMESTER**

|  |  |  |  |  |  |  |  |  |  |  |  |
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| **Sl. No.** | **Subject**  **Type** | **Subject Code** | **Subject**  **Name** | **Teaching Hours** | | | **Credit** | **Maximum Marks** | | | |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Core 3 | PPCCE205 | Applied Hydraulics | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 2 | Core 4 | PPCCE206 | Ground Water Hydrology | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 3 | Professional Elective 3  (Any One) | PPECE212 | Water Quality Modeling & Management | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPECE213 | Remote sensing and GIS Application in Water Resources Engineering |
| PPECE214 | Hydrometry, Water acts and Water services |
| 4 | Professional Elective 4  (Any One) | PPECE215 | Fluvial Hydraulics | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPECE216 | Hydrologic system Modeling |
| PPECE217 | Ground water Assessment and Development |
| 5 | Practical 1 | PPRCE201 | Minor Project & Seminar | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| 6 | Lab 3 | PLCCE205 | Design of Irrigation System Lab | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| 7 | Lab 4 | PLCCE206 | Hydrology Engineering Lab | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| **Total** | | | | **12** | **0** | **12** | **18** | **120** | **280** | **300** | **700** |
| 8 | Audit 2 | Any one subject from Appendix-II | | | | | | | | | 100 |
| **Grand Total** | | | | | | | | | | | **800** |

**3rd SEMESTER**

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| **Sl. No.** | **Subject**  **Type** | **Subject Code** | **Subject**  **Name** | **Teaching Hours** | | | **Credit** | **Maximum Marks** | | | |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Professional Elective 5  (Any One) | PPECE307 | Computational Fluid Dynamics (CE) | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPECE308 | Finite Elements in Water Resources Engineering |
| PPECE309 | Environment Impact And Risk Assessment |
| 2 | Open Elective | Any one subject from Appendix-III | | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 3 | Project 1 | PPRCE301 | Phase-I Dissertation | 0 | 0 | 20 | 10 | - | - | 100 | 100 |
| **Total** | | | | **6** | **0** | **20** | **16** | **60** | **140** | **100** | **300** |

**4th SEMESTER**

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| **Sl. No.** | **Subject**  **Type** | **Subject Code** | **Subject**  **Name** | **Teaching Hours** | | | **Credit** | **Maximum Marks** | | | |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Project 2 | PPRCE401 | Phase-II Dissertation | 0 | 0 | 32 | 16 | - | - | 100 | 100 |
| **Total** | | | | **0** | **0** | **32** | **16** | **-** | **-** | **100** | **100** |

**Abstract of Credit and Marks Distribution**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl. No.** | **Semester** | **Maximum Credits** | **Maximum Marks** |
| 1 | 1st Semester | 18 | 800 |
| 2 | 2nd Semester | 18 | 800 |
| 3 | 3rd Semester | 16 | 300 |
| 4 | 4th Semester | 16 | 100 |
| **Total** | | **68** | **2000** |

**NB:**

* **Any one of the Courses in Appendix-I is to be Decided by the Concerned Department for Audit-1 (1st Sem)**
* **Any one of the Courses in Appendix-II is to be Decided by the Concerned Department for Audit-2 (2nd Sem)**
* **Any one of the Courses in Appendix-III is to be Decided by the Concerned Department for Open Elective (3rd Sem)**

**Semester-1**

**Core 1: Advanced Fluid Mechanics (CE) (PPCCE105)**

**Course Objective:**

1. To derive the partial differential equations governing the conservation of mass, momentum, and energy of an incompressible Newtonian fluid.
2. To obtain dimensionless forms of the governing equations, and from these extract the dimensionless parameters that determine the flow field and present some exact solutions to the Navier-Stokes equations.
3. To obtain knowledge about turbulence, diffusion and their applications on fluid mechanics
4. To derive the boundary layer equations and show how to obtain exact and approximate integral solutions.

**MODULE- I**

**Introduction to Fluid Mechanics:** Structure of Fluid Mechanics; Fluid Type, Motion Characteristic and spatial Dimensionality Consideration; Quantitative Definition of Fluid and Flow, Reynolds Transport Theorem, Mass, Momentum and Energy Conservation Principles for Fluid Flow.

**Kinematics of Flow**: Equation of continuity in Cartesian, polar and cylindrical coordinates, rate of deformation, dilation, vorticity.

**Potential Flow**: Frictionless I rotational Motions, 2 - D Stream Function and Velocity Potential Function in Cartesian and Cylindrical Polar Coordinate Systems, Standard Patterns of Flow, Source, Sink, Uniform Flow and irrotational vortex, Combinations of Flow Patterns

**MODULE-II**

**Viscous Flow:** Study of Local Behavior, Differential Approaches in Analysis of Viscous Flows Equations of motion for laminar flow of a Newtonian fluid - Viscous flow – Navier-Stoke’s equations, Approximate solutions to N-S Equations

**Turbulence:** Origin of turbulence, universal velocity distribution, laws of turbulence. Turbulent Flow obtained from N – S Equations, Models for Turbulence, Theories of Turbulent Shear Stresses, Velocity Distribution in Smooth and Rough Pipes, Resistance Coefficients for Pipes

**MODULE –III**

**Diffusion:** Equations of Fluid Dynamics for a Mixture of Fluids, Dispersion of Pollutants in a Fluid Medium, Coefficient of Mass Transfer.

**Boundary Layer Theory**: Boundary Layer Concept, Prandtl’s Boundary Layer Equations, Laminar Boundary Layer along a Flat Plate, Integral Momentum Equation, Blassius Solution. Turbulent Boundary Layer and Boundary Layer Separation, Applications of Boundary layer concept to real life problems, Drag and lift, Applications of Boundary layer concept to real life problems.

**Text/Reference Books:**

1. Som S. K and Biswas G “Introduction to Fluid Mechanics and Fluid Machines”, TMH
2. Schlichting: “Boundary Layer theory”, International Text – Butterworth
3. White, F.M. “Viscous Fluid Flow”, McGraw Hill Pub. Co, NYork
4. Yalin, M.S. “Theory of Hydraulic Models”, McMillan Co.
5. Fox R.W., Pitchard P.J, and Mcdonald A “Fluid Mechanics” Wiley India.
6. Rouse, H. “Advanced Fluid Mechanics”, John Wiley & Sons, NYork
7. Mohanty A.K. “Fluid Mechanics”, Prentice Hall of India, Delhi.
8. K. Subramanya, Theory and application of Fluid Mechanics, Tata Mc Grawhill, New Delhi.
9. Jain, A.K. Fluid Mechanics and Hydraulic machines
10. Patra K.C. “Engineering F.M.to Hydraulic Machines, Narosa Publishing House, Delhi

**COURSE OUTCOMES:**

Upon completion of this course students will be able to:

1. Review and understand the continuity, momentum and energy equations for viscous, incompressible fluids and understand vorticity and circulation concepts and theorems.
2. Understand and utilize approximate solutions of the Navier-Stokes equation and Have a fundamental understanding of analytic and numerical methods used to solve fluid dynamics problems.
3. Understand the usage of tables and charts to determine properties for problem solutions and use the skill to develop models of real processes and systems and draw conclusions

**Core 2: Advanced Hydrology (PPCCE106)**

**Course Objective:**

1. To analyze hydrological modeling over varying spatial (catchment to global) and temporal scales.
2. To understand fundamental mechanisms of hydrologic cycle with the probabilistic approaches will be discussed in a logical progression. land-atmosphere interactions in relation to large-scale hydrological modeling, surface water-groundwater interactions in the context of increasing water exploitation, climate change, and sea level rise, use of remote sensing in hydrology, and human-water interactions.

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| **Module-I**  Statistics and Probability in Hydrology:  Probability and probability distributions – basic concepts, Properties of random variables ‘Some discrete distribution and applications in earth sciences, Normal distribution and other continuous distributions, Parameter estimation theory and methods, Time series analysis.  **Module-II**  **Hydrograph Theory:** Components of hydrograph, base flow separation, direct runoff hydrograph, Unit hydrograph theory, derivation of unit hydrograph, S-hydrograph and instantaneous unit hydrograph, Derivation of unit hydrograph for ungauged catchments, conceptual models - Time Area Diagram, Clark model, Nash model, Dooge models, synthetic unit hydrograph and its derivation  **Flood Estimation:** Peak discharge estimation procedures, deterministic and probabilistic **approaches, enveloping curve, rational method, SCS and unit hydrograph methods, Design flood, return period, flood frequency analysis**, probabilistic and statistical concepts, and time series analysis, Gumbel’s and log Pearson Type III methods.  **Module-III**  **Flood Routing:** Concepts of flow routing, hydraulic and hydrologic routing, Reservoir routing, Channel routing, Muskingum and Muskingum-Cunge methods of channel routing and flood forecasting.  Modelling Approaches in Hydrology:  Hydrological Model: Mathematical models and types, watershed models and types.  PRMS (Precipitation Runoff Modeling System) model, Hydrologic Modeling System (HEC-HMS), MODFLOW, ARIMA.  **Text Books**   1. Chow, V.T, Maidment, D.R., and Mays, L.W., Applied Hydrology, Tata McGraw Hill 2. McCuen, R.H., Hydrologic Analysis and Design, Prentice Hall Inc. N York, 2005 3. Patra, K.C, Hydrology and Water Resources Engineering, Narosa Publications, 2008 4. Singh, V.P. “Hydrologic Systems,”, Prentice Hall Inc., NYork 5. Viessman, W., Lewis, G.L. and Knapp, J.W. “Introduction to Hydrology”, Harper & Row Publications 6. Ponce, W.F. “Engineering Hydrology”, Prentice Hall Inc. NYork. |
| **Course Outcomes:**  Upon successful completion of this course students will be able to:   1. Gain knowledge about fundamentals of hydrology and precipitation types and characteristics. 2. Analyze infiltration process, evaporation process and Calculate runoff using various measurements. 3. Analyze different components of hydrograph, derivation of various types of hydrograph using base hydrograph and formulate various models. 4. Estimate flood using various approaches, flood frequency analysis and methods and analyze flood routing. |

**PE 1: Water Resources Systems Planning and Management (PPECE111)**

**Course Objectives:**

1. To understand about the concepts of system analysis in the planning, design, and operation of water resources.
2. To formulate mathematical optimization methods and various programming models.
3. To use simulation and management techniques in water resources systems and apply this to water quantity management.
4. To analyze economical and legal aspects of Water Resources System and its effect on environment.

**MODULE – I**

**Introduction:**

General Principles of Systems Analysis to Problems in Water Resources Engineering, Water Resources Planning and Development, Nature of Water Resources Systems, Socio Economic Characteristics. Classical Optimization Techniques, Calculus method, Gradient Techniques

**MODULE–II**

**Methods of Systems Analysis:** Linear Programming Models, Simplex Method, Sensitivity Analysis, Dual Programming, Dynamic Programming Models,

Stochastic Programming, Simulation, Search Techniques, Multi Objective Optimisation.

**Water Quantity Management:** Surface Water Storage Requirements, Storage Capacity and Yield, Reservoir Design, Water Allocations for Water Supply, Irrigation, Hydropower and Flood Control, Reservoir Operations, Planning of an Irrigation System, Irrigation Scheduling, Groundwater management, Conjunctive Use of Surface and Subsurface Water Resources.

**MODULE –III**

**Economic Analysis of Water Resources System:** Principles of Engineering Economy, Capital, Interest and Interest Rates. Time Value of Money, Depreciation, Benefit Cost Evaluation, Discounting Techniques, Economic and Financial Evaluation, Socio-Economic Analysis.

**Legal Aspects of Water & Environment Systems:** Principles of Law applied to Water Rights and Water Allocation, Water Laws, Environmental Protection Law, Environmental Constraints on water Resources Development.

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| Text/Reference Books: |
| 1. Loucks, D.P., Stedinger, J.R. and Haith, D.A. (1982) “Water Resources Systems Planning and Analysis”, Prentice Hall Inc. NYork |
| 1. Chaturvedi, M.C. (1987), “Water Resources Systems Planning and Management”, Tata McGraw Hill Pub. Co., NDelhi. |
| 1. Hall. W.A. and Dracup, J.A. (1975), “Water Resources Systems”, Tata McGraw Hill Pub. NDelhi |
| 1. James, L.D. and Lee (1975), “Economics of Water Resources Planning”, McGraw Hill Inc. n York |
| 1. Kuiper, E. (1973) “Water Resources Development, Planning, Engineering and Economics”, Buttersworth, London |
| 1. Biswas, A.K. (1976) “Systems Approach to Water Management”, McGraw Hill Inc. N York |
| 1. Taha H A, (1996), “Operations Research”, Prentice Hall of India, NDelhi.   **COURSE OUTCOMES:** |

Upon completion of this course students will be able to:

1. Know about the general concepts and problems of water resource system and management.
2. Apply optimization methods to solve problems related to water resource systems.
3. Use simulation models for planning and design of Water Resources Systems.
4. perform basic economic analysis to evaluate the economic feasibility of water resources projects

**PE 1: Design of Hydraulic Structures and Hydro Power Engineering (PPCCE112)**

**Course Objectives:**

1. To understand the basics of hydro power, classification of hydro plants.
2. To know the basics of Hydraulic structures along with the design of different components associated with it.
3. To analyze various hydraulic structures like concrete dam and spillway.
4. To get knowledge of various types of dam and understand different elements of dam.

**MODULE –I**

**Introduction:** Sources of Energy, Status of hydro power in the World. Transmission Voltages and Hydro-power, estimation of water power potential, General load curve, load factor, capacity factor, utilization factor, diversity factor, load duration curve, firm power, secondary power, prediction of load.

**Classification of Hydel Plants:** Run off river plants, general arrangement of run off river plants, valley dam plants, diversion canal plants, high head diversion plants storage and pondage, Pumped storage plants: Types of Pumped storage plants, relative merits of two unit and three unit arrangement. Three-unit arrangement, reversible pump turbines, problems of operation, power house, efficiency of P-Splants.

**Water Conveyance:** Classification of penstocks, design criteria for penstocks, economical diameter of penstock, anchor blocks, conduit valves, types of valves, bends and manifolds, illustrative, water hammer, resonance in penstocks, channel surges, surge tanks.

**Intakes:** Types of intakes, losses of intakes, air entrainment at intakes, inlet aeration, canals fore bay, tunnels.

**MODULE –II**

**Tidal power:** Basic principle, location of tidal power plant, difficulties in tidal power generation, components of tidal power plants, modes of generation, single basin arrangement, double basin system.

**Concrete Dams:** Investigation and Planning. Forces on Concrete dams, Types of loads, Stability analysis. Safety criteria, Gravity analysis, Internal stress calculation and Galleries. Joints and keys and cooling arrangement. Water stops at joint, closing gaps. Buttress and Arch Dam. Mass concrete for dams: Properties and quality control. Pressure grouting.

**Spillway:** Types, Design principles of Ogee spillway, side channel spillway, Chute spillway, Siphon Spillway, shaft Spillway, Gates & Valves. Energy dissipators and stilling basin design. Outlet works.

**MODULE –III**

**Earth and rock fill Dams:** subsurface explorations methods, cutoff trenches, sheet piling cutoffs, upstream blankets, horizontal drainage blankets and filters, toe drains and drainage trenches, pressure relief well. Seepage through embankments, Stability analysis of slopes of homogeneous and zoned embankment type under different reservoir conditions, Upstream and downstream slope protection measures.

**COURSE OUTCOMES:**

Upon completion of this course students will be able to:

1. Enhance knowledge on various concepts of hydro power generation and types of Hydel plants.
2. Select type of hydraulic structure and estimate tidal power, capacity and water load lines throughout various hydraulic structures.
3. Perform structural design and analyze the various aspects of different hydraulic structures.
4. Be able to select the type of dam, design and to construct.

**PE 1: Modeling, Simulation and Optimization (PPECE113)**

**Course Objectives:**

1. To gain knowledge about fundamentals of systems and various models in computational field.
2. To analyze time series relation and spatial distribution aspects.
3. To apply knowledge of engineering mathematics to solve random variable problems.
4. To solve various mathematical problems using various simulation methods and optimization programming.

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| **MODULE I**  **Systems and Models:** Fundamentals of systemic approach, system modeling, classification of models, model structure, Linear, non-linear, time-invariant, time variant models, State-space models, Distributed parameter models, System Synthesis, Direct and inverse problems, Role of optimization, Role of computers, examples fromhydrology/water resources engineering |
| **Regression Analysis:** Linear and Multiple Regression analysis, analysis of residues,tests of goodness of fit, Parsimony criterion, role of historical data, examples from hydrology / water resources Engineering. |
| **Spatial Distribution**: Polynomial surfaces, Kirging, Spline functions,ClusterAnalysis |
| **MODULE II**  **Time Series Analysis:** Auto-cross correlation analysis, identification of trend, spectral analysis, identification of dominantcycles, smoothening techniques, Filters,time series of rainfall and stream flow. |
| **Random variables:** Basic concepts, probability density distribution functions, Expectation and standard deviation of discrete and continuous random variables and their functions, covariance and correlation, commonly used theoretical probability distributions (uniform, normal, binomial, poisson’s and negative exponential), Fitting distributions to raw data, Chi-square and Kolmogrov-Smirnov;s tests of the goodness offit, Central limit theorem, various algorithms for generation of random numbers. |
| **MODULE III**  **Monte Carlo simulation:** basic concepts, generation of synthetic observations,statistical interpretation of output, Evaluation of definite integrals. |
| Optimization: Introduction, Classical methods, Linear Programming, DynamicProgramming, Nonlinear optimization, Constrained optimization techniques. |
| **Text/Reference Books:** |
| 1. Law, A.M. and Kelton, W.D., “Simulation Modeling and Analysis”, Tata McGraw Hill, 2007. |
| 1. Daniel, C. and Wood, P.S., “Fitting Equations to Data”, John Wiley, 1980. |
| 1. Ljung, L., “System Identification Theory for the Users”, Prentice Hall, 1999. |
| 1. Rao S. S., “Engineering Optimization,Theory and Pratice”, New Age International Publishers, 2012. |
| 1. Deb, K., “Optimization for Engineering design”, Prentice Hall of India, 2006. |
| 1. Vedula S. and Mujumdar P. P. “Water Resources Systems”, Tata McGraw Hill, 2005. |

**PE 2: Advanced Numerical Methods (PPECE104)**

**COURSE OBJECTIVES:**

1. To apply Computer oriented methods for solving numerical problems in science and engineering
2. To solve Numerically systems of simultaneous linear equations, nonlinear algebraic equations (root solving), differentiation and integration, ordinary differential equations, interpolation.

**Module I:**

*Introduction:* Introduction to numerical methods and analysis and computer programming; *Error Analysis:* Approximations; Round off and Truncation errors; Error Analysis. *Roots of Equations (single variable)*: Method of Bisection, Regular Falsi, Secant Method, Fixed point Method, Newton Raphson method, Multiple roots. Analysis and order of convergence. *Polynomials:* Mueller’s method, Bairstow’s method.

*Solution of Linear System of Equations*: Dense, Sparse and Banded systems, Direct Methods -Gauss Elimination, Gauss-Jordan, LU decomposition, Thomas Algorithm. Condition number of matrix, effect of round-off errors. Iterative improvement of solution by direct methods. Iterative methods: Jacobi and Gauss Seidel iteration, rate of convergence of iterative methods. Successive over Relaxation. *Solution of Nonlinear System of Equations*: Iterative methods, Fixed Point iteration, Newton-Raphson method.

**Module II:**

*Approximation Theory*: Approximation of Continuous functions -basis functions, norms and semi-norms, inner product, formulation of least square problem, derivation of normal equations, orthogonal basis functions. Tchebycheff and Legendre polynomials. Interpolating polynomials: Newton’s divided difference polynomial, Lagrange polynomials. Interpolation using spline functions: linear, quadratic and cubic splines. *Polynomial regression* of discrete data. Transformation of nonlinear problems to linear approximation problems. *Eigenvalues and Eigenvectors*: Power method, inverse power method. *Fadeev-Leverrier method* for formulation of the Characteristic polynomials, QR decomposition.

**Module III:**

*Numerical Differentiation:* Introduction to finite difference approximations, truncation error analysis. Finite difference approximations on irregular grid. Richardson’s extrapolation. *Numerical Integration*: Rectangular rule, Trapezoidal Rule and Simpson's rule. Local and global error analysis. Romberg Integartion. Gauss Quardrature, Improper Integrals. *ODE, Initial Value Problems*: Euler's method, improvement of Euler's method, Runge -Kutta Methods, Multi Steps Methods. Predictor Corrector Methods. *ODE, Boundary Value Problems*: Decomposition into Linear System of ODEs, Shooting Method, Direct Method. *Partial Differential Equations*: Elliptic, Parabolic and Hyperbolic Equations, Explicit and Implicit Methods, Crank Nicholson Method.

**References**

1. Jain M.K, SRK Iyenge and RK Jain, “Numerical Methods for Scientific &Engg. Computation”.
2. Mathews J. H “Numerical Methods for Mathematics, Science and Engineering”.
3. Gerald C.F and PO Wheatley “Applied Numerical Analysis”.
4. Gupta S.C and V. K. Kapoor “Fundamentals of Applied Statistic”, Sultan Chand & Sons.
5. Johnson R.A “Probability and Statistics for Engineers.”
6. Rajeshwaran S, “Numerical Methods in Science & Engineering (A Practical Approach)”, Willey Publication.

**COURSE OUTCOMES:**

After the completion of the course the students will be able to

**1:** Familiarize with finite precision computation, numerical solutions of nonlinear equationsin a single variable.

**2:** Familiarize with numerical interpolation and approximation of functions, numerical integration and differentiation.

**3:** Familiarize with numerical solution of ordinary differential equations.

**4:** Familiarize with calculation and interpretation of errors in numerical methods

**PE 2: Application of Soft Computing Techniques (PPECE114)**

**Course Objectives:**

1. To familiarize with soft computing concepts.
2. To gain knowledge about basics of ANN and neural network modeling**.**
3. To understand basics of the fuzzy logic concepts, fuzzy principles and relations.
4. To apply knowledge of neuro fuzzy application and formulate neuro fuzzy modeling.

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| **MODULE –I** |
| Introduction to Artificial Intelligence. Basics of MATLAB. Programming in MATLAB: Scripts and Functions, Graphics |
| **MODULE –II** |
| **Fundamental concepts of Artificial Neural Networks:** Model of a neuron, activation functions, neural processing, Network architectures, learning methods.  **Neural network Models:** Feed forward Neural Networks, Back propagation algorithm, Applications of Feed forward networks, Recurrent networks, Hopfield networks, Hebbian learning, Self organizing networks, unsupervised learning, competitive learning. |
| **MODULE –III** |
| **Fuzzy Set Theory:** Basic definitions and terminology and membership functions – Formulation and parameters, basic operations of fuzzy sets – complement, intersection vision, T-norm and T- conorm.  **Fuzzy Reasoning and Fuzzy Inference:** Fuzzy relations, Fuzzy rules, Fuzzy reasoning, Fuzzy Inference Systems, Fuzzy modeling, Applications of Fuzzy reasoning and modeling in Civil Engineering Problems. |
| **Neuro - Fuzzy Modelling:** Neuro-Fuzzy inference systems, Neuro-Fuzzy control. **Applications of Neuro-Fuzzy computing:** Hydrologic Modelling time series Analysis and modeling, , Prediction of watershed runoff, Optimal reservoir operation. |

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| **Text/Reference Books:** |
| 1. Jang, JSR, C.T. Sun and E. Mizutani (1997), “Neuro-Fuzzy and Soft Computing”, Prentice Hall, NJ. |
| 1. Haykin, S.(1994), “Neural Networks, A Comprehensive Foundation”, McMillan College Publishing Company |
| 1. Kosko, B. (1997),”Neural Networks and Fuzzy Systems”, Prentice Hall of India Pvt. Ltd., New Delhi |
| 1. Rao V and H. Rao, (1996), “C++” Neural Networks and Fuzzy Logic, BPB Publications, NewDelhi. |
| 1. Pratap R (2010). Getting Started with MATLAB, OXFORD Publication. |

**COURSE OUTCOMES:**

Upon completion of this course students will be able to:

1. List the facts and outline the different process carried out in fuzzy logic and ANN.

2. Apply Soft computing techniques to solve character recognition, pattern classification, regression and similar problems.

3. Explain the concepts of soft computing and familiar with various computing soft wares.

4. Evaluate various techniques of soft computing to defend the best working solutions.

**PE 2: Advanced Irrigation and Drainage Engineering (PPECE115)**

**Course Objectives:**

1. To gain knowledge about various irrigation types, suitability and requirement.
2. To design various types of hydraulic structures like canals, head regulators and cross regulators using different factors.
3. To understand infiltration process and gain knowledge about fundamentals of surface irrigation hydraulics.
4. To analyze types, principle and needs of drainage system.

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| **MODULE- I** |
| **Introduction**: objectives of irrigation, type of irrigation and suitability; selection of irrigation method. Irrigation requirement, water balance, soil water relationships, water storage zone, infiltration. Flow of moisture through root zone, soil physical and chemical properties, crop evaporative and drainage requirements, irrigation efficiency and uniformity. |
|  |
| **Design of lined and unlined channels**: Design for clear and sediment laden water, principles of maximum and minimum permissible velocities, theory of sediment transport, discharge measuring devices. Design of distributaries head regulator and cross regulator: Hydraulic design principles, seepage theory, exit gradient, invert filter, protection works. |
| **MODULE-II** |
| **Infiltration**: infiltrometer, ponding methods, soil water, tensiometers, neutron probe, time Domain reflectometer, evapotranspiration, crop coefficient, leafarea index, FAO guidelineson evapotranspiration estimation. |
| Fundamentals of surface irrigation hydraulics, continuity equation, momentum equation Hydrodynamic model, zero inertia model, kinematic wave model. |
| **MODULE- III** |
| **Types of drainage system, surface drains**: layout and design of surface drains, their operation and maintenance.  Drainage principles, need for drainage, steady state equations,. Salt balance, water and salt balance of the root zone, salt equilibrium equation and leaching requirement, leaching efficiency. |
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| **Text/Reference Books**: |
| 1. Walker, W.R., and Skogerboe, G.V., "Surface Irrigation Theory and Practice", Prentice Hall, INC. |
| 1. Drainage Principles and Applications," International Institute for Land Reclamation and Improvement",Wageningen. |
| 1. Michael, A.M., "Irrigation: Theory and Practice", Vikas Publishing House. |
| 1. Asawa, G.L., "Irrigation Engineering", New Age International Publishers. |
| 1. Majumdar, D.K., “Irrigation Water Management”, PHI Learning. |
| 1. Luthin, J.N., "Drainage Engineering", John Wiley. |

**COURSE OUTCOMES:**

Upon completion of this course students will be able to:

1. Understand the concept of soil-water-plant relationship and can apply it to schedule irrigation.
2. Design various hydraulic structures.
3. Learn about infiltration process and fundamentals of surface irrigation hydraulics.
4. Know about types, principle and needs of drainage system.

**MC: Research Methodology & IPR (PMCMH101)**

**Module I:**

Introduction to RM: Meaning and significance of research. Importance of scientific research in decision making. Types of research and research process. Identification of research problem and formulation of hypothesis. Research Designs.

Types of Data: Primary data Secondary data, Design of questionnaire; Sampling fundamentals ad sample designs, Methods of data collection, Measurements and Scaling Techniques, Validity & Reliability Test.

**Module II:**

Data Processing and Data Analysis-I, Data editing, Coding, Classification and Tabulation, Descriptive and Inferential Analysis, Hypothesis Testing- Parametric Test (z test, t test, F test) and non-parametric test (Chi square Test, sign test, Run test, Krushall-wallis test).

**Module III:**

Data Analysis II: Multivariate Analysis- Factor Analysis, Multiple Regression Analysis. Discriminant Analysis, Use of Statistical Packages.

**Reference Books:**

1. Research Methodology , Chawla and Sondhi, Vikas

2. Research Methodology, Paneerselvam, PHI

**Course Outcomes:**

**CO1:** Understood the Meaning of research problem, Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

**CO2:** Got the knowledge of How to get new ideas (Criticizing a paper) through the Literature Survey (i.e. Gap Analysis).

**CO3:** Understood the Filing patent applications- processes, Patent Search, Various tools of IPR, Copyright, Trademarks.

**CO4:** Understood How to apply for Research grants and Significance of Report Writing, Steps in Report Writing, Mechanics and Precautions of Report Writing, Layout of Research Report.

**CO5:** Got the knowledge of How to write scientific paper & Research Proposal - Structure of a conference and journal paper, how (and How Not) to write a Good Systems Paper:

**Lab 1: Hydraulic Engineering Laboratory (PLCCE105)**

**Course Objectives:**

1. To design experiments on various aspects of open channel and hydraulic jump.
2. To demonstrate hydraulic principles used in engineering design and apply them for solving problems.
3. To develop skills for analyzing experimental data, designing and conducting experiments, and working in teams.

**List of experiments**

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| 1. Measurement of velocity profile in straight and meandering open channel; |
| 1. Experiments on velocity distribution and Boundary shear in rough and smooth channels, |
| 1. Discharge measurement byweir to find critical depth and Surface profile; |
| 1. Characteristics of Hydraulic Jump in horizontal and Sloping Channels |
| 1. Determination of Manning’s N for Composite Sections |
| 1. Velocity Distribution in Open Channels and momentum correction Factors |
| 1. Drag coefficients of flow past cylinders |
| 1. Boundary layer velocity profile. |
| 1. Energy loss in Bends |
| 1. Analysis of Distribution Networks   **COURSE OUTCOMES:** |

Upon completion of this course students will be able to:

1. Understand open channel cross sections, hydrostatic pressure distribution and Manning’s law.
2. Determine water surface profiles, boundary layer and Velocity distribution profile for different types of flow

in open channels.

1. Analyze distribution networks, energy loss in bends and drag coefficient of flow past cylinder.

**Lab 2: Software Lab (PLCCE106)**

**Course Objectives:**

# To gain knowledge about satellites and visual interpretation techniques.

# To demonstrate ARC GIS software and perform various tool work using the software.

# To apply software techniques to prepare maps and legends.

# To formulate various models in the field of surface water, ground water, catchment using Software

**List of Experiments:**

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| 1. Study of different types of satellite data |
| 1. Visual interpretation of satellite images of different resolutions. |
| 1. Demo on ARC GIS |
| 1. Extraction of thematic information from satellite images Mapping of Land use and land cover Geological and structural features |
| 1. Digitization of Points and Lines Editing Map Elements |
| 1. Attribute Data Entry and Manipulation |
| 1. Building and Transformation Data Analysis – Overlay, Buffer |
| 1. Map Generation with Patterns and Legends |
| 1. Introduction to QGIS s/w |
| 1. Modeling of surface water, ground water, catchment |
| **COURSE OUTCOMES:**  Upon completion of this course students will be able to: Learn about satellites, visual interpretation techniques.Perform ARC GIS and QGIS software.Prepare models using various techniques and software. **Audit-1**  **[To be decided by the Department]: Refer Appendix-I** |

**Semester-2**

**Core 3: Applied Hydraulics (PPCCE205)**

**Course objectives: -**

1. To develop an understanding of continuity, momentum and energy equations to uniform and non-uniform open channel flows
2. To understand the flow of water through open channels and sediment transport
3. To develop an understanding of continuity, momentum and energy equations to uniform and non-uniform open channel flows and to learn to apply conservation laws to gradually varied and rapidly varied unsteady flows.
4. To analyze hydraulics of mobile bed channel
5. To give an idea about bridge hydraulics.

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| **Module I** | | |
| Basic Concepts of Free Surface Flow, classification of flow, velocity & pressure distribution. Conservation laws, continuity equation, momentum equation, Uniform flow, Section of constant velocity, Specific energy, Specific force, Critical depth, Critical slope, limit slope, Section factor, First hydraulic exponent M, Second hydraulic exponent N, Channel Transitions, Compound section. | |
| Module II | |
| Non-uniform flow: Gradually varied flow, Characteristic of surface profiles, Integration of varied flow equation, Direct step method. Rapid Varied flow: Application of conservation laws, Hydraulic jump, classification, location and length of hydraulic jump, jumps in Non- rectangular channel, Jumps as energy dissipater, Surges in open channel, Positive surges, Negative surges, Dam break problem | |
| Module III | |
| Hydraulics of Mobile bed channel, Initiation of Motion of sediment, Critical analysis of Shield’s diagram, Bed forms, and Predication of bed form. Design of stable channels: Critical tractive force approach | |
|  | |
| Bridge Hydraulics: Introduction to Bridge Hydraulics: Water ways, Afflux, Scour: Local scour, abutment scour, Indian practice of design for scour. | |
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| Text/Reference Books: |
| 1. Chow .V.T. “Open Channel Hydraulics”, McGraw Hill . New York |
| 1. Henderson. “Open Channel Flow”, McMillan Pub.London.. |
| 1. Subramanya, K “Flow in Open Channels”, Tata McGraw Hill Pub., 1995 |
| 1. Garde and Ranga Raju, K.G. “Mechanics of Sediment Transportation and Alluvial Stream Problems”, Wiley Eastem, New Delhi |
| 1. Chaudhry M.H. “Open – Channel Flow”, Prentice Hall of India, New Delhi |
| 1. French, R.H. “Open Channel Hydraulics”, McGraw Hill Pub Co., New York |
| 1. Hamill L. (1999), Bridge Hydraulics, E & FN Spon,London |

## Course outcomes:

## By the end of the course applied of hydraulics, the students will be able to --

## Ability to apply continuity, momentum and energy equations to uniform and non-uniform open channel flows.

## Apply conservation laws to gradually varied and rapidly varied unsteady flows .

1. Ability to analyse hydraulics of mobile bed channel.

## Know about bridge hydraulics.

**Core 4: Groundwater Hydrology (PPCCE206)**

**Course objectives:-**

1. To get concept of various surface and subsurface geophysical methods for groundwater explorations
2. To provides an insight into forecasting and behaviour of a regional aquifer system.
3. To know about design principles of well
4. To understand concept for groundwater management and modelling

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| **MODULE- I** |
| **Hydrogeology**: Porosity and Permeability of Rocks, Groundwater in Igneous, Metamorphic, Sedimentary Rocks, Hydrogeological Regions of India.  Occurrence of ground water: Origin, Hydrologic cycle, Water balance, geological formations as aquifers, type of aquifers, groundwater basins, springs. Isotropic and anisotropic aquifer  **Well Hydraulics:** Darcy’s Law, validity of Darcy’s Law, permeability, laboratory and field measurement of permeability, groundwater Flow lines. Steady flow to a well, steady radial flow to a well in confined aquifer and unconfined aquifer |
| Unsteady radial flow into a confined aquifer, Non equilibriumTheis equation, Theis method of solution, Cooper-Jacob method, Chow’s method, Recovery of drawdown, Cyclic discharge, partially penetrated well, well loss, step-drawdown method, Unsteady radial flow into unconfined aquifer, multiple well system, Leaky aquifer, Image well theory  **MODULE-II**  **Well Construction:** Shallow and Deep well, Methods of constructions of shallow and deep wells, Cable tool, Hydraulic rotary method, Well development, Well screen, Well completion, testing of wells for yield |
| **Geophysical Exploration:** Aerial photo interpretation, remote sensing applications to ground water exploration, test drilling, Surface and Subsurface investigations of groundwater  **Groundwater Fluctuations:** Seasonal and secular variations, fluctuation due to irrigation, stream flow, rainfall and miscellaneous causes.  **MODULE-III**  **Artificial recharge of Ground water:** By water spreading, through pits and shaft, recharge through other methods  **Groundwater pollution:** Municipal sources, liquid wastes from domestic uses, solid wastes, Industrial sources, tank and pipeline leakage, Mining activity, agricultural sources, septic tank and cesspools, saline water intrusion in coastal aquifers, methods to control saline water intrusion |
| **Groundwater Management:** Concepts of Basin management, Equation of hydrologic equilibrium, Groundwater basin investigations, conjunctive use of surface and groundwater.  Groundwater Modeling: Groundwater Flow, mathematical, Analog and Digital modeling |

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| Text/Reference Books: |
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| 1. Todd, D.K. “Groundwater Hydrology”, John Wiley & Sons,Singapore |
| 1. Raghunath, H.M. “Groundwater”, Wiley Eastern Ltd, NDelhi 2. Davis, S.N. and De Weist, R.J.M. “Hydrogeology”, John Wiley & Sons, New York |
| 1. Bear, J., "Hydraulics of Ground Water", McGraw. |
| 1. Sharma, H.D.and Chawla, A.S.“Manual on Ground water and Tube Wells”,Technical Report No. 18, CBIP, New Delhi, |
| 1. Domenico “Concepts and models in Groundwater Hydrology”, McGraw Hill Inc. New York |
| 1. Garg, S.P. “Groundwater and Tube Wells”, Oxford and IBH Publishing C. New Delhi. |
| 1. Freeze and Cherry, "Ground Water", Prentice Hall. |
| 1. Driscoll, F.G., "Ground Water and Wells", Johnson Division. |

## Course outcomes:

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

1: Know about various surface and subsurface geophysical methods for groundwater explorations.

2: Understand about well hydraulics.

3: Know about design principles of well

4: Understand the basics of groundwater management and modeling.

**PE 3: Water Quality Modeling and Management (PPECE212)**

**Course objectives:-**

1. To develop an understanding of monitoring the water quality.
2. To provide the knowledge on transport and transformation of contaminants in ground water.
3. To learn about Estuaries
4. To understand concept for groundwater quality management

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| **MODULE- I** |
| **Water quality description**: Various characteristics of water, water quality criteria and standards, elements of reaction kinetics, spatial and temporal aspects of contaminant transport, transportmechanism-advection,diffusion,dispersion;Riverandstreams,convective  Diffusion equation and its application. |
| **MODULE-II** |
| **Estuaries**: Estuarine hydraulics, Estuarine water quality models; Lakes and reservoirs, eutrophication; Contaminant transport in unsaturated flows, solute transport models for conservative species, solute transport in in spatially variable soils. |
| **MODULE- III** |
| **Contaminant transports in ground water advection**: Dispersion, one dimensional transport with linear adsorption, dual porosity models, numerical models, bio degradation reaction. |
| **Water quality management**: Socio-economic aspects of water quality management, management alternatives for water quality control, waste load allocation process, lake quality management, ground water remediation. |

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| **Text/Reference Books:** |
| * 1. Thomann and Muller, Principles of surface water quality modeling and control |
| * 1. Chapra, Surface water quality modeling. |
| * 1. Schnoor, Environmental Modeling. |
| * 1. Thomann, System Analysis And Water Quality Management |
| Course outcomes:\_ Upon successful completion of course the students will be able to :  1: Understand and interpret water quality data for beneficial uses in water quality models.  2: Have knowledge on transport and transformation of contaminants in ground water.  3: Understand the basics of groundwater quality management |

**PE 3: Remote Sensing and GIS: Application in Water Resources Engineering (PPECE213)**

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| **Course objectives:-**  1: To understand the interaction of electromagnetic interaction with matter by using remote sensing.  2: To learn to integrate remote sensing and GIS analysis.  3: To develop an understanding of remote sensing and GIS applications in water resources engineering.  **MODULE- I :** |
| **Remote Sensing**  Basic Concepts of Remote sensing: Definition, Principle of remote sensing, Electromagnetic spectrum, interaction of EMR, Spectral reflectance curve.  Remote sensing System: Satellite and orbit, Resolutions, Multispectral, Thermal, Hyper spectral remote sensing.  Data: acquisition platforms, products, Data analysis: Visualization, interpretation, image classification. |
| **MODULE-II :** |
| **Geographic Information System**  Introduction to GIS: Definition and terminologies, GIS architecture, components of GIS, the four Ms, Advantages and disadvantages of GIS.  GIS data models: Spatial data models, Database models. Process of GIS: data capture, data sources, data encoding, data analysis.  Maps: types, scale, symbol, characteristic, use. Coordinate systems: definition, types. Map Projection: definition, types |
| **MODULE- III :** |
| **Application in Hydrology:**  Flood Mapping, surface soil study, land use-land cover, Agriculture: crop mapping and crop monitoring, Forestry: deforestation, burn mapping, Ocean and coastal monitoring: ocean features, sea-surface height and roughness. Case studies |
| **Application in Watershed management** : Flood plain mapping, Soil: soil moisture, characteristic, Planning: rban planning and Regional planning, Case studies |

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| Text/References Books: |
| 1. Remote Sensing and GIS by Basudeb Bhatta, Oxford; Second edition |
| 1. Introduction to Geographic Information System by Kang-Tsung-Chang, McGraw-Hill Higher Education,4th edition. |
| 1. Lillesand T.M. and Kiefer R.W., “Remote Sensing and Image Interpretation”, John Wiley and Sons, N York. |
| 1. Meijerink A. M. J., H. A. M. de Brouwer, C. M. Mannaerts and C. R. Valenzuela, “Introduction to the use of Geographic Information Systems for Practical Hydrology”, ITC Publication, Paris. |
| 1. Swain P.H., and S.M. Davis, “Remote Sensing – The Quantitative Approach”, McGraw Hill Publishing Company, N York. |
| 1. John G. Lyon, “GIS for Water Resource and Watershed Management”, CRC Press. |
| Course outcomes: Upon successful completion of course the students will be able to :  1: Integrate remote sensing and GIS analysis.  2: Know about scope of remote sensing and GIS in water resources and environmental systems. |

**PE 3: Hydrometry, Water Acts and Water Services (PPECE214)**

**Course Objectives:-**

1. To have knowledge of real time data acquisition and transmission system

2. To understand concept of procedure for water allocation and pricing

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| **MODULE-I** |
| Real time Data Acquisition and transmission system, Data Bank and Instant Hydro-meteorological Data Querry System for River Basins, Use of Acoustic Doppler Current Profiler ( ADCP), Accoustic Doppler velocimeter, Flow Tracker for discharge measurement , Digital flow measuring devices for pipe flow. |
| **MODULE-II** |
| Sewer Analysis, Surface Hydrologic Modeling, Subsurface Modeling in Water Resources Environmental Flow. |
| Land acquisition, RR, Right to fair compensation and transparency in land acquisition, Rehabilitaion and resettlement act. Critical Issues in Land Acquisition in LA and RR. |
| Canal Acts and Rules, Brief Introduction to IS Codes, Water Law Framework, Odisha Irrigation act and Rules, Pani Panchayat Act, Minitoring various committees, Funding Agencies and Monitoring Committees for Water resources projects. Procurement Guidelines. EPC Contract Methodology and Bidding: Appointing PEC, PMF, TPAI for Turnkey Projects for effective monitoring. |
| **MODULE-III** |
| Procedure for Water Allocation to Industrial / Commercial and other establishments (in different states). Pricing and recovery procedure for Industrial / Commercial and other establishments.Odisha Irrigation acts and rules. Lift Irrigation, Broad conceptual planning of a Mega Lift Scheme, Distribution network planning and design. |

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| **Texts/Reference Books:** |
| 1. Gupta S V. (2002) Practical Density Measurement and Hydrometry. Institute of Physics Publishing. Bristol. 2. IndiaWater Acts 3. Pani Panchayat Rules 4. LandAquisitionRules 5. Canal Act Rules 6. Irrigation Acts and Rules   **Course Outcomes**:  Upon successful completion of course the students will be able to:  1: Identify the Real Time Data Acquisition and transmission system  2: Analyze the Critical Issues in Land Acquisition in LA and RR.  3: Understand the Procedure for Water Allocation and Pricing; and recovery procedure. |

**PE 4: Fluvial Hydraulics (PPECE215)**

**Course Objectives: -**

1: To understand the concepts of sediment properties, sediment transport and its assessment.

2: To introduce the flow characteristics in an alluvial channel with erodible boundary and their Hydraulic Geometry

3: To analyze hydraulics of mobile bed channel

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| **MODULE- I** | |
| **Introduction**: Nature of sediment problems, origin of sediments, Fundamental properties of individual sedimentary particles, bulk properties of sediments. | |
| **Incipient motion:** competent velocity, lift concept, critical tractive force. | |
| **Regime of Flow:** Description of Regime of flow, Types of regimes of flow, Importance of Regimes of flow, prediction of regimes of flow.  **Bed load transport**: Derivation of bed load transport equation based on dimensional analysis, semi-theoretical equations. Saltation | |
| **MODULE- II** | |
| **Suspended load transport:** Mechanics of suspension, General equation of diffusion, sediment distribution equation.  **Total load transport**: Two approaches to the problem, Microscopic method, Macroscopic methods.  **Alluvial Streams and their Hydraulic Geometry**: Geomorphic cycle, various stages of streams, nature of bed materials, variable in stream problems. | |
| **MODULE- III** | |
| **Stream Bed Variation**: Continuity equations for sediments, equilibrium depth of scour in long channels, stream bed changing during floods, degradation, Aggradation | |
| **Sediment control**: Methods of sediment control in canal, river training works for control of sediment in rivers and streams, reservoir sedimentation, best management practices for control of reservoir sedimentation. | |
| Text/Reference Books: |
| 1. Garde, R.J., “River Morphology”, New InternationalPublishers. |
| 1. Julien, P.Y., “Erosion and Sedimentation”, Cambridge UniversityPress. |
| 1. Jansen, P.P.H., “Principals of River Engineering”, VSSDPublications. |
| 1. Garde, R.J. and Ranga Raju, K.G., "Mechanics of Sediment Transport and Alluvial Stream Problems", Wiley EasternLimited. |
| **Course Outcomes**:  Upon successful completion of course the students will be able to:  1: Analyze the concepts of sediment properties, its transport and assessment.  2: Understand hydraulics of mobile bed channel |

3: Apply field applications in the domain of hydraulics

**PE 4: Hydrologic System Modeling (PPECE216)**

**Course Objectives:**

1. To study occurrence movement and distribution of water that is a prime resource for development of a civilization.
2. To know diverse methods of collecting the hydrological information, which is essential, to understand surface water hydrology.
3. To analyze the concepts of probability distributions and design frequencies.

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| **MODULE- I** |
| **Hydrologic cycle**: Climate and water availability, Water balance, Precipitation mechanisms, Measurement of precipitation, Infiltration, Evaporation and transpiration, Surface run off, Hyetographs, Hydrographs, Derivation of UH, S-curve, Climatic Modeling- Regional Climate Models (RCMs) and General Circulation Models (GCMs). |
| **MODULE-II** |
| **Application of UH**: Derivation of an average UH, Conceptual models, Traditional analysis vs. hydrological simulation, Monte-Carlo simulation Generation of random numbers, Simulation of systems with random inputs, Developing synthetic unit hydrograph, Development of rainfall runoff relationship, Flow duration curves, Flood routing. |
| **MODULE- III** |
| **Probability distributions**: Probability functions for hypothesis testing, Statistical analysis for linear regression, Multiple linear regression, Method of parameter estimation, Return period flood estimation, Estimation of flood discharge for a confidence interval, Regional flood frequency analysis, Risk and reliability concepts, Binomial distribution, Poisson distribution. |
| **Design frequencies**: Peak over threshold (POT) models, Mechanical energy and fluid potential, Fluid potential and hydraulic head, Darcy’s law, Gradient of hydraulic head, Aquifer properties, Equation of groundwater flow, Unsaturated Flow: Unsaturated Hydrostatics and Hydrodynamics. |

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| **Text/Reference Books:** |
| 1. K.C. Patra, Hydrology and Water resources Engineering, by Narosa publishing house, New Delhi |
| 1. K. Subramanya, Engineering Hydrology, Tata McGraw Hill BookCompany |
| 1. V.P.Singh,"ElementaryH ydrology", Prentice Hall of India, Pvt. Ltd., New Delhi. |
| 1. V.T. Chow, Hand book of Applied Hydrology, Mc Graw-Hill Publishing Company, New York. |
| 1. M.A. Kohlar, J.L.H Pauluhus, R.K.Linsely, Hudrology for Engineers, Tata Mc Graw Hill, New Delhi. |
| **Course Outcomes**:  Upon successful completion of course the students will be able to :   1. Gain knowledge about hydrological parameters and its measurement procedures. 2. Identify the problems related to hydrological variables by using hydrological tools. 3. To analyze hydrographs for its application in real world problems. 4. Design frequencies and understand probability distribution. |

**PE 4: Groundwater Assessment and Development (PPECE217)**

**Course Objectives:**

1: To have knowledge of groundwater as an important natural resource.

2: To understand the flow towards wells in confined and unconfined aquifers. and the principle involved in design and construction of wells and well hydraulics.

3: To create awareness on improving the groundwater potential using various recharge techniques.

4: To appreciate various geophysical approaches for groundwater exploration.

5: To learn groundwater management using advanced tools.

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| **MODULE- I** |
| **Importance of GW**: Available water on earth, Hydrologic cycle, types of aquifer, storage coefficients, ground water basins, Darcy’s law, permeability, well hydraulics, pumping test, water wells, test holes and well loss, Methods of Drilling of deep wells, cable tool drilling method, rotary method, pumps. |
| **MODULE-II** |
| **Surface investigation of groundwater**: Remote sensing, geophysical exploration, electrical resistivity method, seismic refraction method, gravity and magnetic methods, water witching, sub surface investigation of ground water: test drilling, geologic logging, geophysical logging, resistivity logging. |
| **MODULE- III** |
| **Artificial recharge of groundwater**:  Conjunctive use of water, managing our water resources, Erosion control and watershed development :their benefit towards conservation of national water wealth. |
| **Rain water harvesting and recharge of ground water**: Role of society and People’s participation for sustainable water resource development. Mitigation strategies for flood damage: structural and non-structural measures. |

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| **Text/Reference Books:**   1. Todd, D.K. “Groundwater Hydrology”, John Wiley & Sons,Singapore |
| 1. Ground Water Manuals, A water resources technical Publications, Scientific Publishers, Jodhpur |
| 1. L. Harviland F .G. Bell, Ground Water Resources and Development, Butter worths, London. |
| 1. H.M. Raghunath, Ground Water, New Age International Pvt. Ltd. |
| 1. F.W. Schwartz & H. Zhang, Fundamental of Ground Water, John Willey &Sons. 2. Murty JVS, ”Watershed Management”, New Age International Pvt. Ltd. |
| **Course Outcomes**:  Upon successful completion of course the students will be able to:  1: Analyze radial flow towards wells in confined and unconfined aquifers.  2: Design wells and understand the construction practices.  3: Interpret geophysical exploration data for scientific source finding of aquifers.  4: Determine the process of artificial recharge for increasing groundwater potential.  5: Apply appropriate measures for groundwater management. |

**Mini Project with Seminar (PPRCE201)**

**[To be decided by the Department]**

**Lab 3: Design of Irrigation System and Drainage (PLCCE205)**

**Course Objectives:**

1. To develop storage yield reliability relationship and evaluate performance of single and multi-reservoir system.

2. To analyze crop planning and management of water quality of rivers.

3. To analyze simulation of reservoir, aquifer.

4. To design experiments on water distribution networks and irrigation system.

**List of Experiments:**

1. Development of storage-yield-reliability relationship for a reservoir
2. Developing optimal operating policy for a single and multi-reservoir system
3. Crop planning and irrigation scheduling
4. Water quality management in a river
5. Optimal design of water distribution networks
6. Simulation of operation of a reservoir
7. Simulation of an aquifer
8. Performance evaluation of an irrigation system

**Course Outcomes:**

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

1. Gain practical knowledge about irrigation techniques and their designs.

2. know about drainage techniques and their field uses.

**Lab 4: Hydrology Engineering Laboratory (PLCCE206)**

**Course Objectives:**

1. To analyze precipitation data and determine Average rainfall for given catchment.
2. To determine water quality and parameters, hydrologic properties
3. To perform rainfall runoff studies, measurement of sediment transport.
4. To use computer programs to analyze simulation problems

**List of Experiments:**

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| 1. Measurement of rainfall, evaporation, infiltration, laboratory and field tests. |
| 1. Determination of average rainfall over a catchment. |
| 1. Rainfall – Runoff Studies |
| 1. Determination of Water Quality and Wastewater Parameters |
| 1. Determination of In-situ soil Hydrological Properties |
| 1. Measurement of sediment load; Water balance studies |
| 1. Determination of Infiltration Characteristics |
| 1. Determination of Hydraulic Conductivity with Constant Head Permeameter |
| 1. Computer programs and software applications for hydrologic analysis and simulation problems.   **Course Outcomes:**  Upon successful completion of course students will be able to:   1. Determine average rainfall for given catchment. 2. Analyze rainfall runoff relationship. 3. Determine water quality, parameters, hydrologic properties. 4. Analyze sediment load, simulation problems of hydrology. |

**Audit-2**

**[To be decided by the Department]: Refer Appendix-II**

**Semester-3**

**PE 5: Computational Fluid Dynamics (CE) (PPECE307)**

**Course Objectives:**

1. To use of modern computational fluid dynamics software in water resources engineering. Build, solve, and visualize fluid-flow models to gain a deeper understanding of the principles of fluid mechanics.

**MODULE- I**

Introduction: Benefits and Applications of CFD, Numerical vs. Analytical vs. Experimental, Modeling vs. Experimentation, Fundamental principles of conservation, Reynolds transport theorem, Conservation of mass, Conservation of linear momentum: Navier-Stokes equation, Conservation of Energy, General scalar transport equation.

Finite difference approach: Classification of Partial Differential Equations and Physical Behaviour: Mathematical classification of Partial Differential Equation, Illustrative examples of elliptic, parabolic and hyperbolic equations, Physical examples of elliptic, parabolic and hyperbolic partial differential equations.

**MODULE- II**

Fundamentals of Discretization: Disretizations of the 1-D, 2-D partial differential equations and its solutions. Discretization principles: Preprocessing, Solution, Post processing, 3 Finite difference method, Well posed boundary value problem, Possible types of boundary conditions, Conservativeness, Boundedness, Transportiveness, Finite volume method (FVM), Explicit finite difference schemes, Implicit finite difference schemes, Initial and Boundary conditions, significance of model boundary conditions

**MODULE- III**

Elementary Finite Element: Introduction, Basic concepts of the finite element Method, Use & basic organisation of finite element programs.

Dirichlet, Neumann & Cauchy boundary conditions. Hermitian Elements. Procedures for reducing core storage requirements in finite element programs.

Basic concept of calculus of variations, Accuracy and convergence of finite element method.

**Text/Reference Books:**

1. J.D. Anderson, Jr. Computational Fluid Dynamics. McGraw Hills
2. K.A. Hoffman and S.T. Chiang. Computational Fluid Dynamics. Engg. Education System.
3. M.B. Abbott and D.R. Basco, Computational Fluid Dynamics. (1989).
4. C.B. Vreugdenhill, Computational Hydraulics (1989).
5. S.V. Patankar, Numerical Heat Transfer and Fluid Flow, McGraw-Hill.
6. T. J. Chung, Computational Fluid Dynamics, Cambridge University Press.
7. H.K. Versteeg & W. Malalasekera, An Introduction to Computational Fluid Dynamics, Longman Scientific & Technical.
8. J. H. Ferziger and M. Peric, Computational Methods for Fluid Dynamics, Springer.
9. John C. Tannehill, Dale A. Anderson and Richard H. Pletcher, Computational Fluid Mechanics and Heat Transfer, Taylor &Francis. John D. Anderson Jr, Computational Fluid Dynamics, McGraw Hill Book Company.
10. J. Blazek, Computational Fluid Dynamics: Principles and Applications, Elsevier.
11. FLETCHER - Vol. I, Vol. II, Springer.

**Course Outcomes:**

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

1. Ability to use modern CFD software tools to build flow geometries, generate an adequate mesh for an accurate solution.
2. Ability to analyze a flow field to determine various quantities of interest using flow visualization and analysis tools.
3. Ability to simplify a real fluid-flow system into a simplified model problem, to select the proper governing equations for the physics involved in the system, to solve for the flow, to investigate the fluid-flow behaviour, and to understand the results.
4. To recognize the type of fluid flow that is occurring in a particular physical system and to use the appropriate model equations to investigate the flow

**PE 5: Finite Elements in Water Resource Engineering (PPECE308)**

**Course Objectives:**

1. To understand basics of finite elements as applicable in the water resources area and fluids

**MODULE-I**

Introduction; Finite Element Method, Concepts of elements and nodes, degrees of freedom. Relation between nodal degrees of freedom and generalized coordinates, convergence requirements, natural coordinate systems, shape functions, element stiffness matrix.

Basic Concepts of FEA: Advantages, Disadvantages and Limitations of FEA, Errors and Accuracy of FEA. Basic steps in finite element analysis

**MODULE- II**

Isoparametric elements: Computation of stiffness matrix for isoparametric elements, direct stiffness method of analysis and solution technique, assemblage of elements, direct stiffness method, boundary conditions and reaction.

Analysis of framed structures; Two dimensional truss element, two dimensional beam element, stiffness matrix for a two dimensional beam element with 6 d.o.f., element load vector, transformation matrix, computation of stress resultants, shear deformation, plane stress and plane strain analysis, nodal load vector, rectangular elements, 8 noded rectangle, isoparametric elements

**MODULE- III**

Applications of FEM: Finite Element Formulation: Displacement based finite element formulation, Pressure based finite element formulation.

Steady State Flow: Introduction, Galerkin`s Method, Triangular elements, Assembly of conductance matrix, Boundary conditions. Region near a well example, Seepage through Dam, Poisson’s equation.

Transient Flow: Introduction, Galerkin`s Method, Rectangular elements, Assembly of matrix differential equations, Solving the matrix differential equations, Boundary conditions Reservoir Problem.

Advective-Dispersive Transport: Introduction, Dispersion, Solute transport equation, Solute dispersion in uniform flow field.

**Text/Reference Books:**

1. C.S.Krishnamoorthy, " Finite element analysis, theory and programming", Tata McGraw Hill
2. Cook R.D., Malkus, D.S. and Plesha, M.E., Concepts and Applications of Finite Element Analysis, Third Edition, John Wiley.
3. O.C. Zienkiewicz, The Finite Element Method, Tata McGraw-Hill.
4. Pinder, G. F., Gray, W. G., Finite Elements in Subsurface Hydrology, Academic Press, 1977.
5. Huyakorn, P.S and Pinder, C. F., Computational Methods in Sub-Surface Flow, Academic Press, 1983.
6. Connor, J.C. and Brebbia, C. A., Finite Element Techniques for Fluid Flow, Butterworth, 1976.
7. Taylor, C. and Hughes, T. J. Finite Element programming of the NavierSotckes Equation, Pinerdge Press, 1980.
8. Finlayson, B. A., The method of Weighted Residuals and Variational Principles, Academic Press, 1972.
9. Wang H.F and Anderson M P, Introduction to Groundwater Modelling, Academic Press 1982.

**Course Outcomes:**

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

1. Ability to know about ordinary and partial differential equations and finite difference methods
2. Ability to know application of various hydrodynamic techniques to steady and unsteady flows
3. Ability to know application of finite element method to steady and unsteady flows
4. Ability to perform computer programming of these computational methods

**PE 5: Environmental Impact and Risk Assessment (PPECE309)**

**Course Objectives**

The objective of this course is:

1. To impart knowledge on different concepts of Environmental Impact Assessment.
2. To know procedures of risk assessment
3. To learn the EIA methodologies and the criterion for selection of EIA methods.
4. To pre-requisites for ISO 14001 certification
5. To know the procedures for environmental clearances and audit
6. To appreciate the importance of stakeholder participation in EIA

**MODULE- I**

Introduction (Preliminary Assessment): Overview and Introduction to the Course, The Environmental Impact Assessment Process, Basic Steps in EIA Process, EIA Notifications of MoEF, Project Screening and scoping for EIA, Initial Environmental Examination, public participation in environmental decision making. Prediction and Assessment of Impacts on the Air Environment: Air Pollutants Emission, Ambient Air Quality and Standards, Emission Inventories, Meteorological Data, Mass Balances, Dispersion Models, Pollutant Emissions Minimization - Case Study

**MODULE- II**

Prediction and Assessment of Impacts on the Surface Water Environment: Quality Impacts, Quantity Impacts, Water Quality Index, Mass Balances, Quantitative Modeling, Water Conservation - Case Study. Prediction and Assessment of Impacts on the Groundwater Environment: Hydrogeological Information, Vulnerability Mapping, Subsurface Transport and Fate.

**MODULE- III**

Prediction and Assessment of Impacts on the Noise Environment: Terminology, Noise Propagation from Point and Line Sources, Mitigation Measures - Case Study 4. Biological Impact Prediction and Assessment: Identifications, Related laws, Biological indices & Mitigation measures 4 6. Prediction and Assessment of Impacts on the Socioeconomic Environment: Selection of Factors, Risk and Health, Socioeconomic Gains versus Biophysical Losses.

Prediction and Assessment of Impacts on the Land Environment: Soil & Geological properties, Universal Soil Loss equation, mitigation measures, Risk Assessment: Hazard Identification, Effect Assessment, Risk characterization, Risk Reduction, Environmental audit. Case studies of EIA.

**Text/Reference Books:**

1. Jain R.K., Urban, L.V. and Stacey, G.S., “Environmental Impact Analysis”, Van Nostrand Reinhold. 2003
2. Weathern, P., “Environmental Impact Assessment – Theory and Practice”, Unwin Hyman, London. 1982 3.
3. Canter, L.W., “Environmental Impact Assessment”, McGraw Hill. 2006
4. Charles, H., “Environmental Impact Assessment”, CRC Press. 2011
5. Morris, Peter and Riki, “Methods of Environmental Impact Assessment”, Spon Press, London.

**Course Outcomes**

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

1. Prepare EMP, EIS, and EIA report
2. Identify the risks and impacts of a project
3. Selection of an appropriate EIA methodology
4. Evaluation the EIA report
5. Estimate the cost benefit ratio of a project
6. Know the role of stakeholder and public hearing in the preparation of EIA

**Open Elective**

**[To be decided by the Department]: Refer Appendix-III**

**Project 1: (PPRCE301)**

**[To be decided by the Department]: Dissertation (Phase-I)**

**Semester-4**

**Project 2: (PPRCE401)**

**[To be decided by the Department]: Dissertation (Phase-II)**