INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Hydrology

Subject Code: HYC-501 **Course Title:** Open Channel and Fluvial Hydraulics

L-T-P: 2-0-2 **Credits:** 3 **Subject Area**: PCC

Course Outlines: Review of fundamentals of hydraulics, hydrostatics and hydrodynamics; Open channel flow, basic features, uniform flow, critical flow, specific energy, specific energy diagram, flow transitions, momentum principles, hydraulic jumps and computer assisted calculations; Steady state gradually varied flow, governing differential equation, characteristics and classification; step methods, direct integration method, graphical integration method of water surface profiles, computer oriented algorithms; Transient gradually varied flow, Saint Venant's equations, simplified hydraulic routing methods- diffusion wave theory, computer oriented algorithms; Regime channels, design of stable channels, critical tractive force approach; Overview of hydraulic modeling software

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Hydro and Renewable Energy

Subject Code: HYC-503 **Course Title:** Stochastic Hydrology

L-T-P: 2-1-0 **Credits:** 3 **Subject Area**: PCC

Course Outlines: Fundamentals of probability theory, Fundamentals of hydrologic time series analysis, Analysis of trends and periodicity using non-parametric and parametric tests, Analysis of stochastic component and stochastic models, Design flood estimation for gauged and ungauged catchments using stochastic models, Flood estimation under climate change, Single site and multi-site synthetic data generation, Rainfall forecasting, Flow forecasting using stochastic models, Auto correlation and spectral analysis, range and storage analysis, Data-driven analysis using advanced techniques.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Hydrology

Subject Code: HYC-507 **Course Title:** Deterministic Hydrology

L-T-P: 2-1-0 **Credits:** 3 **Subject Area**: PCC

Course Outlines: Systems concept, Hydrological systems, hydrological cycle as a complex system, unit hydrograph theory and methods, Prediction in ungauged basins. Design storm and design flood estimation for gauged and ungauged basins using CWC methods and recent developments, Linear conceptual models of direct runoff, such as Nash, Dooge, Clark and Flood routing, Calibration of conceptual models and model evaluation measures. Nonlinearity in hydrology. Introduction to nonlinear deterministic and physically based surface flow models, Flow forecasting using deterministic models, Basics of hydrological modelling using HEC-HMS, HEC-RAS and SWAT models.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Departments of Hydrology

Subject Code: HYC-509 **Course Title:** Surface Water Quality Modelling

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Review of water quality, concept, characterization and assessment, issues of water quality in surface and subsurface, monitoring and analysis about basic paramenters like biochemical oxygen demand, chemical oxygen demand, dissolved oxygen, pathogens, nutrients, algae etc. Modeling concept and their types for water quality, conservation laws, advection and dispersion, mass balance equation, fate and transport of pollutants in water bodies, point and non-point sources of contamination, sedimentation, degradation, decay etc. Exposure to current and advanced management strategies for water quality, treatment for pollutants and emerging contaminants, system engineering concepts design experiments etc.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Hydrology

Subject Code: HYC 511 **Course Title:** Groundwater Hydrology

L-T-P: 2-0-2 **Credits:** 03 **Subject Area**: PCC

Course Outlines: Foundational aspects of groundwater dynamics and management, historical development and scope of groundwater hydrology, aquifer types, properties, and methods for estimating hydraulic conductivity. Representative elementary volume, Darcy's law application in porous media and the derivation of groundwater flow equations, steady and unsteady flow into wells, test pumping analysis, and well hydraulics. Groundwater budgeting, groundwater exploration techniques, artificial recharge methods, relevant legislation and case studies.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Hydrology

Subject Code: HYC 513 **Course Title:** Environmental Quality

L-T-P: 2-0-2 **Credits:** 3 **Subject Area**: PCC

Course Outlines: Components of environment and their interaction; Concepts from environmental chemistry, microbiology and ecology; Environmental processes in aquatic and terrestrial systems; Water, air and soil quality concepts and issues; Sources of pollution; Analytical methods and instruments; Physical, chemical and biological parameters and their estimation; Analytical quality control; Mandates and monitoring networks of government organizations; Design of monitoring networks; Analysis and interpretation of water quality data; Case studies.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Hydrology

Subject Code: HYC-517 **Course Title:** Systems Analysis and Applications in Hydrology

L-T-P: 2-0-2 **Credits:** 3 **Subject Area**: PCC

Course Outlines: System definition, characteristics, component, types and constraints; Systems analysis, techniques, advantages and limitations; Linear programming: graphical method, simplex method, dual of linear programming, big-M method and dual simplex method, sensitivity and parametric analyses, and interior-point methods; Dynamic programming: Bellman's principle, principle of optimality, recursive equation representation, tabular method, example applications of dynamic programming; Non-linear programming: classical optimization techniques, constrained and unconstrained nonlinear algorithms, Lagrange multiplier method and Kuhn-Tucker conditions; Multi-objective planning: non-inferior solutions, plan formulation: weighting method, constraint method, and plan selection; Applications in reservoir planning, watershed management and groundwater management; Review of water resources systems software.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Hydrology

Subject Code: HYC-521 **Course Title:** Watershed Behaviour and Conservation Practices

L-T-P: 2-1-0 **Credits:** 3 **Subject Area**: PCC

Course Outlines: Physical elements of a watershed, effects of land use changes on hydrological cycle components, concept of vegetative management of water yield and quality; ecosystem services: benefits to human societies, watershed planning, monitoring and assessment, watershed experiments, extrapolation of results from representative and experimental basins, regional studies; estimation of runoff using SCS and rational method suggested for Indian conditions, watershed development in India, case studies, water and wind erosion process, factors affecting erosion, types of erosion, assessment of erosion, universal soil loss equation, control measures for erosion, special topics: wetland systems, water harvesting techniques, development of modern harvesting techniques.

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPARTMENT: Department of Hydrology

Subject Code: HYS-501 **Course Title:** Natural Resources, Society and Environment

L-T-P: 2-0-0 **Credits:** 2 **Subject Area:** SSC

Course Outlines: Introduction to Earth's resources and their environmental interactions. Energy resources, petroleum and renewables, mineral extraction processes, and associated pollution. Soil and water resources, composition, pollutants, global usage, and degradation. Testing soil and water quality parameters, sustainable resource use and environmental awareness through case studies and group projects.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Departments of Hydrology

Subject Code: HYS-502 **Course Title:** Rural Water Supply and Sanitation

L-T-P: 2-0-0 **Credits:** 2 **Subject Area:** SSC

Course Outlines: Rural environment, sources of water and demands, planning and construction of direct and community water supply schemes; source protection measures; cost effective water treatment technologies. Types and sources of waste; solid and liquid waste management; low cost sanitation planning and construction including household, community toilets; compost pits, vermin composting, biogas plants, low cost drainage. Segregation, disposal and reuse of household waste. Public health, hygiene and sustainable community. Social, cultural, political and economic aspects linked to water and sanitation practices. Pro-community policies, programs. Current conditions and trends in water and sanitation services in low and middle-income countries, lessons learned, key interventions, strategies for improvement. Soft skills, case studies and projects.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Hydrology

Subject Code: HYC 505 **Course Title:** Remote Sensing and GIS Applications

L-T-P: 2-0-2 **Credits:** 3 **Subject Area**: PCC

Course Outlines: Principles of Remote Sensing, Electromagnetic Radiation, Satellite Programs and Sensors, Image Interpretation, Image classification methods, Coordinate Systems, Data Input and Editing, Basic GIS Analysis, Spatial Analysis, DEM analysis, interpolation. GPS and KML, Global Positioning System, Land Use/Land Cover Classification, flood mapping, groundwater studies, erosion/sedimentation analysis, watershed delineation.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Hydrology

Subject Code: HYC-515 **Course Title:** Hydrologic Elements and Analysis

L-T-P: 2-1-0 **Credits:** 3 **Subject Area**: PCC

Course Outlines: Hydrological cycle, catchment water balance; Characteristics of Atmosphere; Atmospheric circulation; weather systems; water vapour, precipitable water, Indian monsoon; Precipitation, IDF and DAD analysis; Interception; Evaporation, Evapotranspiration; Infiltration; Hydrometry; Runoff, unit hydrograph, Synthetic Unit Hydrographs, IUH, Clark and Nash IUH; flow duration analysis, flow mass analysis, estimation of peak runoff, Hydrologic Flood Routing.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Hydrology

Subject Code: HYT-501 **Course Title:** Data Analysis and Numerical Modelling

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** STAR

Course outlines: Introduction to data analysis; Basic concepts of probability and statistics; Probability distributions and their applications; Frequency analysis, Risk and uncertainty in hydroclimatic analysis; Hypothesis testing and nonparametric test; Time series analysis; Regression analysis; Data visualization; Review of differential equations in water resources, Introduction to numerical methods; Finite difference approximation of first and second order derivatives, Forward, backward and central difference methods; explicit, implicit and Crank Nicholson schemes, numerical errors, stability and convergence criteria, Basics of Finite element methods; Iterative methods.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Hydrology

Subject Code: HYL-501 **Course Title:** Water Resources Planning and Management

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** PEC

Course Outlines: Introduction to water resources planning and management. Reservoir capacity and yield using mass curves. Flow-duration curve and dependable flows using ranking method and class interval method. Reservoir sediment distribution using empirical area reduction method and area increment method. Conjunctive water-use planning. Reservoir operation and flood routing. Reservoir routing using Pul's method for flood control, reservoir operation using SOP and zoning methods. Integrated river-basin development. Inter-basin river water transfers. Cost benefit analysis. Reservoir planning for single- and multi-purpose reservoirs. Introduction to MIKE – BASIN software and CROPWAT software for planning water resources projects.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Hydrology

Subject Code: HYL-502 **Course Title:** Urban Hydrology

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** PEC

Course Outlines: Urbanization process, urban planning, land use/land cover changes, hydrological impacts of urbanization, urban hydrologic cycle and processes, rainfall analysis, IDF curves, design storm computation, urban runoff computations, abstractions, Rational Method, overland flow computation, empirical methods, SCS method, time-area and unit hydrograph approaches, stream flow routing, guidelines for designing urban drainage structures, urban storage, stormrunoff, piped and open channel drainage, mixed storm and wastewater transport, urban water supply, demand estimation, surface and groundwater sources, potable water quality, urban flood modeling with SWMM and MOUSE, rainwater harvesting.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTARTMENT: Department of Hydrology

Subject Code: HYL-503 **Course Title:** Irrigation and Drainage Engineering

L-T-P: 2-1-0 **Credits:** 3 **Subject Area**: PEC

Course Outlines: Soil-water-plant relationship, Drainable Porosity, Water requirement of crops; evapotranspiration, Irrigation water requirement, duty-delta relationship, Irrigation methods; design of irrigation channels; Irrigation Efficiency, irrigation economics; Land Drainage; surface and sub-surface drainage system design, Drainage of Sloping Lands, Drainage of Heavy Clay Soils; Salt Balance of the Root zone, Reclamation of Salt-Affected Soils.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Hydrology

Subject Code: HYL-504 **Course Title:** Geophysical Investigations

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** PEC

Course Outlines: Overview of geophysical techniques for groundwater exploration, electrical resistivity methods, potential distribution, electrode configurations, current flow, vertical electrical sounding, profiling, tomography, inversion of resistivity data, correlation with geology, Dar Zarrouk parameters, transmissivity and hydraulic conductivity estimation, VLF, GPR, TDEM methods, induced polarization in sandy zones, seismic refraction for bedrock evaluation, magnetic and gravity methods, geophysical well logging, resistivity logs, self-potential logs, gamma logs, neutron gamma logs, aquifer properties, groundwater quality estimation.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Hydrology

Subject Code: HYL-505 **Course Title:** Surface Water Modelling and Simulation

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** PEC

Course Outlines: Hydrologic Simulation Overview: Classification of Hydrological Models, Components, System Identification, Conceptualization, Implementation, Documentation. Event-Based Models: Theoretical Background. Continuous Models: Theoretical Background. Numerical Solution Techniques, Parameter Optimization, Calibration, Validation. Open Source and Commercial Simulation Models: Hydrological Modelling, Forecasting. Catchment-Scale Modelling: TOP MODEL. Large-Scale Modelling: VIC Model. Ethics in Modelling.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Hydrology

Subject Code: HYL-506 **Course Title:** Soil and Groundwater Contamination Modelling

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** PEC

Course Outlines: Complexities of pollution sources, causes, and classification, contaminants relevant in the Indian context. Solute movement principles in soil and groundwater systems, continuity equations, Fick's law, and mass transfer phenomena. Adsorption processes, equilibrium and kinetic adsorption for reactive and non-reactive solutes. Direct and inverse problems incontaminant transport modelling, numerical methods for steady and transient flows, and multiphase contamination considerations. Pollution control and remediation measures such aspump-and-treat systems, permeable reactive barriers, bioremediation, and density-driven flow phenomena.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTARTMENT: Department of Hydrology

Subject Code: HYL-507 **Course Title:** Hydrometeorology and Climate Change

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** PEC

Course Outlines: Hydrometeorology, The Earth System, Carbon Cycle, Atmosphere Thermodynamics, Radiation and Temperature, Monsoon Mechanism, Climate Variability and Climate Dynamics, Climate Change.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Hydrology

Subject Code: HYL-508 **Course Title:** Vadose Zone Hydrology

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** PEC

Course Outlines: Soil physics, unsaturated permeability, soil water retention models, hysteresis, anisotropy, non- linear permeability, pedotransfer functions, soil moisture measurement, monitoring, infiltration theories, Green-Ampt model, time of ponding, deep percolation, recharge, soil-water-plant relationships, irrigation requirements, evapotranspiration models, leaf area index, crop coefficient, soil moisture stress, root compensation, hydraulic redistribution, salinity stress, moisture dynamics, Richards Equation, water uptake, solute uptake kinetics, analytical and numerical soil water flow solutions, Hydrus1D and 2/3D modelling, macropore flow, preferential flow, solute transport, breakthrough curves, soil thermal properties, heat flow in soils.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTARTMENT: Department of Hydrology

Subject Code: HYL-509 **Course Title:** Ecohydrology

L-T-P: 2-1-0 **Credits:** 3 **Subject Area**: PEC

Course Outlines: Ecohydrology and its principles; Interactions between hydrologic cycle and ecosystems; Biogeochemical cycles; Water and nutrient budgets in terrestrial and aquatic ecosystems; Ecohydrological measurements and upscaling issues; Ecohydrological models; Climate-ecosystem interactions; Ecohydrological effects of climate change; Case studies on ecohydrological approach; Ecosystem services and assessment.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTARTMENT: Department of Hydrology

Subject Code: HYL-510 **Course Title:** Membranes for Desalination and Purification

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** PEC

Course Outlines: The fundamentals of purification, membrane technologies and desalination to overcome water scarcity. Separation processes include microfiltration, ultrafiltration, nanofiltration, membrane distillation, forward osmosis, membrane bioreactors and reverse osmosis membrane processes, electrodialysis, flash-related desalination processes. Membrane fouling/scaling, materials, operational issues, limitations, system configuration and design.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTARTMENT: Department of Hydrology

Subject Code: HYL-511 **Course Title:** Hydrological Data Collection and Processing

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** PEC

Course Outlines: Overview of hydrometeorological data types, errors, and validation. Ground-based, radar, and satellite-based observations of rainfall, snow, evapotranspiration, soil moisture, temperature, humidity, and evaporation, and solar radiation. Streamflow, sediment transport, and groundwater monitoring (including GRACE). Data validation, network design and optimization, missing data estimation, and relevant Indian data portals.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Hydrology

Subject Code: HYL-512 **Course Title:** Numerical Methods in Hydrology

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** PEC

Course Outlines: Water resources systems, hydrological modeling, model types, development, calibration, verification, differential equations in water resources, numerical methods, finite difference approximations, forward, backward, central difference methods, explicit and implicit schemes, Crank Nicholson scheme, numerical errors, stability, convergence criteria, method of characteristics, ADI method, finite element basics, iterative methods, Jacobi, Gauss-Seidel, successive over-relaxation, Picard and Newton-Raphson techniques, tridiagonal matrices, Thomas algorithm, minor project with analytical and numerical simulations.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Hydrology

Subject Code: HYL-513 **Course Title:** Environmental Planning and Assessment of Projects

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** PEC

Course Outlines: Nature of planning and concepts of integrated environmental planning; Population growth and water demands; Types of projects and propelling issues; Description of environmental setting and indicators; Natural factors in environmental planning; Natural and manmade hazards, Biogeochemical cycles and biodiversity resources; Environmental indices: concepts, formulation and application for impact and vulnerability assessment in water, air and ecology; Impact assessment framework and methods: matrix, checklist, network, MCDM, SWOT methods; Environmental modelling for impact prediction and management: air and water quality models; Contemporary and emerging issues in environmental planning: SUDS, SDGs, Water footprint assessment, Ecosystem services, Environmental flows; Casestudies.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Hydrology

Subject Code: HYL-515 **Course Title:** Hydrogeochemistry

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** PEC

Course Outlines: Fundamental geochemical principles and applications in water systems. Unique properties of water, elements, ions, and gases, geochemical reactions and thermodynamic principles. Surfacewater and groundwater composition, contaminant speciation, and controls on solubility. Acid-base equilibria, redox reactions, carbonate geochemistry, and mineral-water interactions. Fate of geogenic and anthropogenic contaminants, sampling techniques, and laboratory analysis methods.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Hydrology

Subject Code: HYL-516 **Course Title:** Soft Computing Techniques

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** PEC

Course Outlines: Overview of soft computing techniques in hydrology, Fuzzy logic, Artificial neural networks, Genetic algorithms, and other soft computing techniques, Advantages and limitations of soft computing techniques in hydrology, Data Mining, Data Standardization and Normalization methods, Error Performance Matrices, Model Assessment Criteria, Overview and practical aspects of Artificial Neural Networks and Fuzzy Logic, Integrationof soft computing techniques for hydrological modelling, Introduction to wavelets, Wavelet- ANNs and other hybrid approaches, Case studies of hybrid soft computing techniques to develop hydrological model, Data assimilation, Big data, Network Theory, Data Merging Approaches, Bayesian Approach.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Hydrology

Subject Code: HYL-518 **Course Title:** Hydro-informatics

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** PEC

Course Outlines: Introduction to hydro-informatics and brief overview of real-time applications, Big data in hydrology-data collection, storage, distribution and processing, Data life cycle, Data model, data model design and implementation, Introduction to information systems, decision supportsystem, spatial decision support systems, web-based information system, expert systems, Emerging computing methods in hydrology using MATLAB.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTARTMENT: Department of Hydrology

Subject Code: HYL-519 **Course Title:** Watershed Modeling and Simulation

L-T-P: 2-0-2 **Credits:** 3 **Subject Area**: PEC

Course Outlines: Process-based modeling of watershed hydrology with emphasis on need for Watershed Modeling; Modeling Concepts and Objectives; Model Classification: Choice of Model Complexity. Model Inputs: Spatial and Temporal Input Data; Pre-processing of data. Sensitivity and Uncertainty Analysis, Parameter Identification and Estimation. Model Calibration and Validation; Model Evaluation: Mathematical and Operational model verification; Graphical and Goodness-of-Fit procedures. Ethics of Modeling: Class Projects.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Hydrology

Subject Code: HYL-520 **Course Title:** Isotope Hydrology

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** PEC

Course Outlines: Introduction to the global water cycle and isotopic classifications, characteristics of stable and radioactive isotopes, fractionation phenomena, and their natural abundance. Sampling and measurement techniques, principles of detection for radioactive and stable isotopes, and related instrumentation. Impact of changing climate on the water cycle, evapotranspiration, precipitation, and isotopic signatures in snow and glacier melt processes. Related applications in surface water hydrology, groundwater hydrology, and environmental hydrology: residence time determination, streamflow measurement, groundwater origin and dating, contaminant tracing, case studies and recent advancements.