DEPARTMENT OF CIVIL ENGINEERING

SIKKIM MANIPAL INSTITUTE OF TECHNOLOGY

PROPOSED SYLLABUS FOR

M.Tech IN

HYDROLOGY AND WATER RESOURCE ENGINEERING

(Applicable for 2025-26 batch onwards)

SMIT SIKKIM MANIPAL UNIVERSITY
SIKKIM MANIPAL INSTITUTE OF TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING
M.TECH IN HYDROLOGY AND WATER RESOURCE ENGINEERING
(Applicable to the students admitted during 2025 and after)

I SEMESTER					
SUBJECT CODE	**SUBJECT**	**L**	**T**	**P**	**C**
MA-2****A	Advanced Engineering Mathematics and Optimization	2	1	0	3
CE-2****A	Advanced Engineering Hydrology	2	1	0	3
CE-2****A	Open Channel Flow and Sediment Transport	2	1	0	3
CE-2****A	Program Elective I	2	1	0	3
CE-2****A	Program Elective II	2	1	0	3
CE-2****A	Hydrology and Hydraulics Lab	0	0	3	1.5
CE-2****A	GIS and Remote Sensing Lab	0	0	3	1.5
CE-2****A	Project Based Learning-I	0	0	4	2
TOTAL		**13**	**2**	**10**	**20**

II SEMESTER					
SUBJECT CODE	**SUBJECT**	**L**	**T**	**P**	**C**
CE-2****A	Hydrogeology and Geohydrology	2	1	0	3
CE-2****A	Irrigation Engineering and Drainage Systems	2	1	0	3
CE-2****A	Water Resources Planning and Management	2	1	0	3
CE-203**A	Program Elective III	I	0	0	3
CE-203**A	Program Elective IV	3	0	0	3
CE-2****A	Modelling Lab (Hydrology/ Hydraulics Software)	0	0	3	1.5
CE-2****A	Python/ MATLAB for Water Resources	0	0	3	1.5
CE-2****A	Project Based Learning-II	0	0	4	2
TOTAL		**13**	**2**	**10**	**20**

III SEMESTER					
CE- 20601A	Dissertation Phase-I	0	0	30	15
TOTAL		**0**	**0**	**30**	**15**

IV SEMESTER					
CE- 20602A	Dissertation Phase-II	0	0	50	25
TOTAL		**0**	**0**	**50**	**25**

PROGRAM ELECTIVE SUBJECTS

CE-2****A - Watershed Management and Modelling
CE-2****A - Environmental Hydraulics
CE-2****A – River Engineering and Sediment Transport
CE-2****A – Stochastic Hydrology
CE-2****A – Groundwater Modelling and Management
CE-2****A - Flood Modelling and Management
CE-2****A – Advanced Irrigation Systems
CE-2****A - Water Quality and Pollution Control
CE-2****A - Remote Sensing and GIS Applications
CE-2****A - Urban Hydrology and Stormwater Management
CE-2****A - Dams and Reservoir Engineering
CE-2****A - Coastal and Estuarine Hydraulics
CE-2****A – Decision Support Systems in Water Engineering
CE-2****A – Hydro power Engineering
*MOOC courses as decided by the Department

MA-2****A	ADVANCED ENGINEERING MATHEMATICS AND OPTIMIZATION	2L: 1T: 0P	3 Credits

Module 1: Solution of Eigen Value Problems: Forward and inverse iteration, Simultaneous iteration, Jacobi – Application to Structural Engg.

[07]

Module 2: Method of Regression: Linear and non-linear regression – Application to Structural Engg.

[08]

Module 3: Introduction to optimization - Engineering applications of optimization - classification of optimization problems.

[07]

Module 4: Classical Optimization Techniques - Single variable, multivariable optimization with and without constraints, Kuhn-Tucker conditions, Linear programming - Standard form of LP problems - graphical methods.

[08]

Module 5: Linear and Non Linear Programming - One dimensional minimization - Elimination methods - Interpolation methods - unconstrained optimisation techniques - direct search methods - Descent methods - constrained optimisation - Direct and indirect methods.

. [08]

Total: 38 hours

References :

1. Rao S.S. (2005), 'Optimization: theory and Practice', Wiley Eastern Limited.
2. Fox, R.L. (1971), 'Optimization methods for Engineering Design', Addison - Wesley, reading mass.
3. Arora, J.S., (1989), 'Introduction to optimum Design' McGraw Hill International editions, N.Y.
4. Goldberg, D.E., (2001), 'Genetic algorithms in search, optimization, and Machine learning', Addison Wesley, Reading Mass.
5. Deb, K., (2002), 'Optimization for Engineering Design, Algorithms and examples' Prentice - Hall of India private Ltd., New Delhi.

CE-2****A	Advanced Engineering Hydrology	2L: 1T: 0P	3 Credits

Module 1: Introduction

Introduction to Hydrology – Hydrologic Cycle, Precipitation, Reynolds Transport Theorem (RTT), Structure and composition of atmosphere, air mass, cold and warm fronts; atmospheric temperature and its variations; vapor pressure and relative humidity; evaporation and evapo-transpiration; types and forms of precipitation; measurement of precipitation and other atmospheric parameters. [12]

Module 2: Rainfall Runoff Process

Runoff Processes – Catchment Characteristics, Rainfall-Runoff Relationships, Streamflow Measurement, Hydrograph Analysis.

[04]

Module 3: Unit Hydrograph and its application

Unit Hydrograph Theory – S-Curve, Synthetic Unit Hydrograph, IUH, Derivations and Applications.

[10]

Module 4: Flood Frequency Analysis

Flood Estimation – Frequency Analysis, Gumbel and Log-Pearson Type III Distributions, Probable Maximum Flood, Risk Analysis.

[06]

Module 5: Design Flood Estimation

Design Storm and Hydrologic Design – IDF Curves, Rational Method, SCS Method, Design Flood Estimation for Structures.

[06]

Total: 38 hours

References:

1. Chow, V.T., Maidment, D.R., Mays, L.W., *Applied Hydrology*, McGraw Hill.
2. Subramanya, K., *Engineering Hydrology*, Tata McGraw Hill.
3. Singh, V.P., *Elementary Hydrology*, Prentice Hall.
4. NPTEL Course: *Advanced Hydrology by Prof. R. K. Goyal*.

CE-2****A	*Open Channel Flow and Sediment Transport* *Alternate Title – River Engineering*	2L: 1T: 0P	3 Credits

Module – 1: Introduction to Open Channel Flow

Open Channel Flow – Uniform and Non-Uniform Flow, Hydraulic Jump, Gradually and Rapidly Varied Flow Equations.

[10]

Module – 2: Steady and Unsteady flow in Open Channels

Steady and Unsteady Flow in Open Channels – Saint Venant's Equations, Kinematic and Diffusion Wave Models, Numerical Solutions.

[08]

Module – 3: Sediment Properties and Mechanics

Properties of sediment: size, density, settling velocity, Initiation of motion and critical shear stress, Modes of sediment transport: bed load, suspended load, total load, Empirical and theoretical sediment transport equations

[08]

Module – 4: River dynamics

Bars in alluvial rivers, river meandering, lateral river migration, riverbed degradation, riverbed aggradation, river confluences and branches, river databases

[06]

Module – 5: River Training and Bank Stabilization

Riverbank stability and protection – riverbank stability, riverbank riprap revetment, riverbank protection, river flow-control structures, river training along braided rivers.

[06]

Total contact hours: 38

References:

1. Reddy, P.J., *A Textbook of Hydraulics and Fluid Mechanics*, Laxmi Publications.
2. Todd, D.K., and Mays, L.W., *Groundwater Hydrology*, Wiley.
3. Jain, S.K., and Singh, V.P., *Water Resources Systems Planning and Management*.
4. NPTEL Course: *Hydraulic Engineering by Prof. R.S. Suresh*.

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CE-2****A	Hydrology and Hydraulics Lab	0L: 0T: 3P	1.5 Credit

Module 1: Rainfall and Runoff Measurement

Rain gauge calibration and rainfall data analysis, Plotting and analysis of hyetograph and mass curve, Measurement and computation of surface runoff from small watersheds.

[06]

Module 2: Infiltration and Evapotranspiration

Double-ring infiltrometer test and analysis of infiltration characteristics., Estimation of evapotranspiration using Class-A pan evaporimeter data, Calculation of crop water requirement using climatological data.

[06]

Module 3: Flow Measurement in Open Channels and Pipes

Calibration of a broad-crested/weir/flume, Determination of Manning's roughness coefficient, Velocity distribution in open channels using current meter or float method.

[09]

Module 4: Groundwater Flow and Aquifer Tests

Pumping test and analysis using Theis/Jacob methods, Observation well data plotting and drawdown estimation, Determination of aquifer parameters using recovery method.

[09]

Module 5: River and Catchment Modeling (Demo/Software-based)

Introduction to software tools like HEC-HMS or SWAT, Demonstration of rainfall-runoff modelling using catchment data, Flow routing simulation in river reaches using HEC-RAS.

[06]

Total: 36 Hours

References:

1. Subramanya, K., *Engineering Hydrology*, Tata McGraw Hill.
2. Ven Te Chow, D.R. Maidment, and L.W. Mays, *Applied Hydrology*, McGraw Hill.
3. HEC-HMS User Manual, US Army Corps of Engineers.
4. Raghunath, H.M., *Hydrology: Principles, Analysis and Design*, New Age International.
5. CWC and BIS codes related to hydrologic and hydraulic measurements.

CE-2****A	GIS and Remote Sensing Lab	0L: 0T: 3P	1.5 Credit

Module 1: Introduction to GIS and RS Software

Overview of GIS and Remote Sensing in Water Resources Engineering, Familiarization with software such as QGIS, ArcGIS, ERDAS Imagine, Coordinate systems and map projections.

[06]

Module 2: Satellite Image Processing and Interpretation

Acquisition and pre-processing of satellite images, Image enhancement techniques: contrast stretching, filtering, band combination, Visual interpretation and supervised/unsupervised classification.

[06]

Module 3: Spatial Data Creation and Digitization

Digitization of hydrologic features (rivers, watersheds, reservoirs), Georeferencing scanned maps and satellite images, Creation of vector layers (point, line, polygon), attribute table editing.

[06]

Module 4: Hydrologic and Watershed Analysis in GIS

Watershed delineation using DEM and flow accumulation, Stream network extraction, catchment area estimation, Calculation of watershed parameters (slope, land use, drainage density).

[09]

Module 5: Integration of GIS with Hydrologic Models

Introduction to HEC-HMS, SWAT model interfaces with GIS, Rainfall-runoff simulation using GIS-based input, Project-based application: hydrologic assessment or flood mapping.

[09]

Total: 36 Hours

References:

1. Lillesand, T.M., Kiefer, R.W., Chipman, J.W., *Remote Sensing and Image Interpretation*, Wiley.
2. Burrough, P.A., and McDonnell, R.A., *Principles of Geographical Information Systems*, Oxford University Press.
3. Chang, K.T., *Introduction to Geographic Information Systems*, McGraw Hill.
4. NPTEL: *Remote Sensing and GIS* by Prof. S.K. Ghosh and Prof. Arun K. Saraf.
5. QGIS User Manual, HEC-GeoHMS, and SWAT Documentation.

CE-2**A**	**PROJECT BASED LEARNING-I**	**0L: 0T: 4P**	**2 Credits**

CE-2****A	COMPUTATIONAL METHODS IN WATER RESOURCES	2L: 1T: 0P	3 Credits

Module 1: **Introduction to Numerical Methods**

Review of errors in numerical computation, Solution of algebraic equations: Bisection, Newton-Raphson, Secant method, Matrix operations and solution of linear systems using Gauss elimination, Gauss-Seidel, and LU decomposition

[06]

Module 2: **Numerical Solution of Differential Equations**

Ordinary Differential Equations (ODEs): Euler's method, Runge-Kutta methods, Partial Differential Equations (PDEs): Finite difference method (FDM) for elliptic, parabolic, and hyperbolic equations, Stability and convergence analysis

[10]

Module 3: **Application to Surface and Subsurface Hydrology**

Numerical modelling of rainfall-runoff transformation, Streamflow routing using kinematic and diffusion wave models, Finite difference schemes for groundwater flow (steady and unsteady)

[08]

Module 4: **Optimization Techniques**

Introduction to optimization, Linear and Non-linear programming models in water resources, Constrained and unconstrained optimization, Dynamic programming and its application in reservoir operations

[07]

Module 5: **Introduction to Computational Tools and Hydrologic Models**

Hands-on problem-solving using MATLAB/Python, Introduction to open-source hydrologic models (e.g., MODFLOW, HEC-HMS, SWAT), Data preparation, model setup, and result interpretation

[07]

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Total: 38 Hours

References:

1. Chapra, S.C., and Canale, R.P., *Numerical Methods for Engineers*, McGraw-Hill.
2. Anderson, M.P., and Woessner, W.W., *Applied Groundwater Modeling*, Academic Press.
3. Singh, V.P., *Computer Models of Watershed Hydrology*, Water Resources Publications.
4. Gupta, S.K., and Gupta, R.P., *Numerical Methods for Engineers*, New Age International.
5. NPTEL: *Computational Hydraulics* by Prof. V.C. Srivastava.

CE-2****A	HYDROGEOLOGY AND GEOHYDROLOGY	2L: 1T: 0P	3 Credits

Module 1: **Hydrogeology**

Introduction / Basic Concept of Hydrogeology / Hydraulic Properties of Rocks / Geological formations – aquifer, aquiclude, aquifuge, aquitard / Types of aquifers / Confined and Unconfined Aquifers / Leakey aquifers / Double-porosity aquifers /Aquifer properties / Factors controlling aquifer recharge and yield / Fracture characterisation.

[08]

Module - 2: Principles of Groundwater Flow and Solute Transport

Groundwater Flow in Fractured rocks / Laminar and Turbulent Flow / Darcy's Law / Groundwater Flow in Fractured rocks / Flow in the Unsaturated Zone / Principles of Solute Transport in Fractured Media

[08]

Module – 3: Subsurface Flow Modelling

Groundwater Flow Modelling – Finite Difference Equations for 2D Aquifers / Boundary Conditions / Steady and Transient Flow / Steady Flow in a Confined aquifer / Steady Flow in an Unconfined aquifer

[08]

Module - 4: Groundwater Quality and Contamination

Groundwater as a Resource / Types of Groundwater Contaminants / Drinking-Water Standards / Risk for Drinking Water / Sources of Groundwater contamination / Relative Ranking of Groundwater contamination / Sources and Substances / Groundwater Contamination as a Long-term Problem / Hydrochemical Zoning and Hydrochemical Facies

[08]

Module – 5: Groundwater Exploration

Hydrogeological Investigations / Types of wells / Hydraulic characteristics of wells / Well-site selection / Hydrogeological investigations / Assessment and Management of Groundwater resources / Water Budget and Groundwater balance / Managed Aquifer Recharge

[08]

Total: 40 Hours

References:

1. Fetter CW, **Applied Hydrogeology** (2000), Prentice Hall, 4th Edition
2. Fetter CW, Boving Thomas, Kreamer David, **Contaminant Hydrogeology** (2009), 3rd Edition.
3. Singhal BBS and Gupta RP, **Applied Hydrogeology of Fractured Rocks** (2010), 2nd Edition Springer

CE-2****A	IRRIGATION ENGINEERING AND DRAINAGE SYSTEMS	2L: 1T: 0P	3 Credits

Module 1: **Fundamentals of Irrigation Engineering**

Irrigation: definition, necessity, advantages, and ill effects, Types and methods of irrigation, Soil-water-plant relationships, Estimation of crop water requirement and irrigation scheduling

[10]

Module 2: **Canal and Conveyance System Design**

Canal alignment and classification, Design of canals using Kennedy's and Lacey's theories, Lining of canals: types, advantages, economics, Canal losses and water conveyance efficiency

[07]

Module 3: **Irrigation Structures and Systems**

Cross-drainage and canal regulation works, Diversion headworks and weirs, Lift irrigation systems and micro-irrigation: drip and sprinkler systems, Command area development and participatory irrigation management

[07]

Module 4: **Drainage Engineering**

Surface and subsurface drainage systems, Design of open and tile drains, Drainage coefficient and spacing of drains, Reclamation of waterlogged and saline soils

[08]

Module 5: **Conjunctive Use and Water Management**

Conjunctive use of surface and groundwater, Irrigation water quality and management strategies, Water logging: causes, effects, and control measures, Case studies and performance evaluation of irrigation and drainage projects

[06]

Total: 38 Hours

References:

1. Michael, A.M., *Irrigation Theory and Practice*, Vikas Publishing House.
2. Punmia, B.C. & Lal, P.B.B., *Irrigation and Waterpower Engineering*, Laxmi Publications.
3. Garg, S.K., *Irrigation Engineering and Hydraulic Structures*, Khanna Publishers.
4. Asawa, G.L., *Irrigation and Water Resources Engineering*, New Age International.
5. NPTEL: *Irrigation and Drainage Engineering* by Prof. N.T.S. Rajan.

CE-2****A	WATER RESOURCES PLANNING AND MANAGEMENT	2L: 1T: 0P	3 Credits

Module 1: **Introduction to Water Resources Systems**

Integrated Water Resources Management (IWRM), Water demand and availability, Classification of water resources systems, Objectives and constraints in water resources planning

[07]

Module 2: Reservoir Planning and Operation

Storage-yield analysis. Mass curve and demand curve, Reservoir operation policies, multi-purpose and multipurpose reservoirs

[08]

Module 3: Economic Aspects of Water Resources Projects

Project appraisal: financial, economic, social, Benefit-cost analysis, Discounting techniques, Internal rate of return (IRR), Net Present Value (NPV)

[09]

Module 4: Optimization in Water Resources Management

Introduction to optimization models, Linear Programming (LP), Dynamic Programming (DP), Application to water allocation and reservoir operation

[06]

Module 5: Decision Support Systems and Sustainability Considerations

Decision-making under uncertainty, Role of GIS and Remote Sensing in planning, Stakeholder participation and sustainability, Case studies in inter-basin transfers, drought management

[08]

Total: 36 Hours

References:

1. Loucks, D.P., and van Beek, E., *Water Resources Systems Planning and Management*, UNESCO.
2. Mays, L.W., *Water Resources Engineering*, Wiley.
3. Vedula, S., and Mujumdar, P.P., *Water Resources Systems*, Tata McGraw Hill.
4. Jain, S.K., and Singh, V.P., *Water Resources Systems Planning and Management*.
5. NPTEL: *Water Resources Management* by Prof. P.P. Mujumdar, IISc Bangalore.

CE-2****A	MODELLING LAB (HYDROLOGY / HYDRAULICS SOFTWARE)	0L: 0T: 3P	1.5 Credit

Module 1: Introduction to Hydrologic and Hydraulic Modelling

Overview of modelling in water resources systems, Introduction to commonly used software: HEC-HMS, HEC-RAS, SWAT, MODFLOW, Understanding input requirements and data preparation

[09]

Module 2: Rainfall-Runoff Modelling using HEC-HMS

Basin model setup, meteorological model, and control specifications, Simulation of runoff hydrographs, Calibration and validation of the model

[09]

Module 3: River and Channel Flow Simulation using HEC-RAS

Geometry creation: cross-section data and reach network, Steady and unsteady flow simulation, Flood inundation mapping and floodplain delineation

[06]

Module 4: Watershed Modelling using SWAT or MIKE SHE

Setup and input data processing (land use, soil, DEM, climate), Hydrologic response unit (HRU) delineation, Water balance analysis, streamflow simulation

[06]

Module 5: Groundwater Flow Simulation using MODFLOW

Aquifer system modelling: layers, properties, and boundaries, Steady and transient state simulations, Visualization of drawdown and groundwater contours

[06]

Total: 36 hours

References:

1. US Army Corps of Engineers, *HEC-HMS and HEC-RAS User Manuals*.
2. Arnold, J.G. et al., *SWAT Model Documentation*.
3. Harbaugh, A.W., *MODFLOW Groundwater Flow Model Documentation*.
4. Singh, V.P., *Computer Models of Watershed Hydrology*, Water Resources Publications.
5. NPTEL: *Hydrologic Modeling*, *Groundwater Modeling*, and *Computational Hydraulics* series.

CE-2****A	PYTHON / MATLAB FOR WATER RESOURCES	0L: 0T: 3P	1.5 Credit

Module 1: Introduction to Scientific Computing

Overview of MATLAB and Python environments for engineering applications, Basic syntax, data types, control structures, and functions, Plotting: 2D and 3D graphs, subplots, contour plots

[09]

Module 2: Matrix Operations and Numerical Techniques

Matrix creation and manipulation, Solving linear systems: Gauss elimination, LU decomposition, Numerical integration and differentiation

[06]

Module 3: Hydrologic Data Analysis and Visualization

Importing and processing rainfall-runoff and streamflow data, Time series analysis, statistical summaries, plotting hydrographs, Regression and correlation analysis for hydrologic modelling

[06]

Module 4: Simulation and Optimization

Solving ordinary differential equations (ODEs) using built-in solvers, Application to storage-routing and reservoir modelling, Linear programming for water allocation problems (e.g., simplex method)

[09]

Module 5: Applications in Water Resources Engineering

Hydrologic model calibration using observed and simulated data, Groundwater table fluctuation modelling using numerical methods, Use of APIs or libraries such as NumPy, SciPy, Pandas, and Matplotlib (Python)

[06]

Total: 36 hours

References:

1. Chapra, S.C., *Applied Numerical Methods with MATLAB*, McGraw-Hill.
2. Rao, S.S., *Applied Numerical Methods for Engineers and Scientists Using MATLAB and C.*
3. MATLAB Documentation – MathWorks: https://in.mathworks.com/help/matlab
4. Python Scientific Stack – NumPy, Pandas, SciPy, Matplotlib official docs.
5. NPTEL: *Numerical Methods in Civil Engineering*, *Scientific Computing using Python*

CE-2**A**	**PROJECT BASED LEARNING-II**	**0L: 0T: 4P**	**2 Credits**

PROGRAM ELECTIVE SUBJECTS

CE-2****A - Watershed Management and Modelling
CE-2****A - Environmental Hydraulics
CE-2****A – River Engineering and Sediment Transport
CE-2****A – Stochastic Hydrology
CE-2****A – Groundwater Modelling and Management
CE-2****A - Flood Modelling and Management
CE-2****A – Advanced Irrigation Systems
CE-2****A - Water Quality and Pollution Control
CE-2****A - Remote Sensing and GIS Applications
CE-2****A - Urban Hydrology and Stormwater Management
CE-2****A - Dams and Reservoir Engineering
CE-2****A - Coastal and Estuarine Hydraulics
CE-2****A - Numerical Methods in Hydrology
CE-2****A – Decision Support Systems in Water Engineering
CE-2****A – Hydro power Engineering
*MOOC courses as decided by the Department

CE2****A	WATERSHED MANAGEMENT AND MODELLING	2L: 1T: 0P	3 Credits

Module 1: Introduction to Watershed Concepts

Definition and delineation of a watershed, Objectives and principles of watershed management, Watershed characteristics and their influence on runoff, Land capability classification and watershed prioritization

[07]

Module 2 Soil and Water Conservation Techniques

Agronomic and engineering measures, Contour bunding, check dams, terracing, vegetative barriers, Runoff and erosion control practices, Rainwater harvesting and groundwater recharge methods

[08]

Module 3: Watershed Hydrology and Modelling Tools

Hydrologic processes at watershed scale, Water balance modelling concepts, Introduction to watershed simulation models (SWAT, WEPP, HEC-HMS), Data requirements and model calibration/validation

[10]

Module 4: Integrated Watershed Management

Socio-economic and institutional aspects, Participatory watershed development and community involvement, Watershed development planning and implementation, Role of GIS and remote sensing in watershed planning

[08]

Module 5: Case Studies and Watershed Evaluation

Evaluation of watershed programs and performance indicators, Case studies of successful and failed watershed projects, Impact assessment using hydrological, economic, and ecological parameters

[06]

Total: 39 hours

References:

1. Murthy, J.V.S., *Watershed Management*, New Age International.
2. Tideman, E.M., *Watershed Management*, Omega Science Press.
3. Neitsch, S.L. et al., *SWAT Model Documentation*, USDA-ARS.
4. NPTEL: *Watershed Management* by Prof. K.N. Tiwari.
5. WMO/UNESCO Manuals on Integrated Watershed Management.

CE2****A	STOCHASTIC HYDROLOGY	2L: 1T: 0P	3 Credits

Module 1 Fundamentals of Probability and Statistics

Basic probability theory and axioms, Random variables and probability distributions, Moments, expectation, variance, covariance, Common hydrologic distributions: Normal, Log-normal, Gamma, Gumbel

[08]

Module 2 Frequency Analysis of Hydrologic Data

Return period and risk analysis, Parameter estimation: method of moments, maximum likelihood, Fitting and testing distributions: Chi-square, Kolmogorov-Smirnov tests
Frequency analysis of extreme rainfall and flood events

[08]

Module 3 Time Series Analysis in Hydrology

Components of a time series: trend, seasonality, randomness, Autocorrelation and partial autocorrelation, Stochastic models: AR, MA, ARMA, ARIMA, Parameter estimation and model diagnostics

[08]

Module 4 Simulation of Hydrologic Processes

Generation of synthetic streamflow and rainfall series, Use of Markov chains for rainfall occurrence modeling, Application of stochastic models for reservoir inflow prediction, Monte Carlo simulation in hydrology

[07]

Module 5 Case Studies and Applications

Drought and flood forecasting using stochastic models, Risk assessment in water resources planning, Real-life applications using Python/MATLAB/R, Review of recent research in stochastic hydrology

[07]

Total: 38 hours

References:

1. Salas, J.D. et al., *Applied Modeling of Hydrologic Time Series*, Water Resources Publications.
2. Wilks, D.S., *Statistical Methods in the Atmospheric Sciences*, Academic Press.
3. Singh, V.P., *Stochastic Hydrology*, Kluwer Academic Publishers.
4. Haan, C.T., *Statistical Methods in Hydrology*, Iowa State Press.
5. NPTEL: *Stochastic Hydrology* by Prof. P.P. Mujumdar, IISc Bangalore.

CE2****A	RIVER ENGINEERING AND SEDIMENT TRANSPORT	2L: 1T: 0P	3 Credits

Module 1 Introduction to River Hydraulics

Classification and morphology of rivers, River equilibrium and regime concepts, Energy and momentum principles in natural streams, River meandering and braiding characteristics

[08]

Module 2 Sediment Properties and Mechanics

Properties of sediment: size, density, settling velocity, Initiation of motion and critical shear stress, Modes of sediment transport: bed load, suspended load, total load, Empirical and theoretical sediment transport equations

[08]

Module 3 River Training and Control Structures

Objectives of river training works, Types: spurs, guide banks, levees, revetments, Design principles and failure mechanisms, Case studies of major Indian river training projects

[08]

Module 4 Sediment Transport Modelling

Governing equations for sediment-laden flows, Bed form development and resistance, Introduction to sediment modeling tools (HEC-RAS, MIKE 11), Numerical approaches for sediment transport simulation

[07]

Module 5 River Morphology and Environmental Aspects

Long-term river behavior and channel migration, Impact of dams and barrages on sediment regime, River ecology and sediment balance, Environmental flows and sediment flushing

[07]

Total: 38 hours

References:

1. Garde, R.J. and Ranga Raju, K.G., *Mechanics of Sediment Transportation and Alluvial Stream Problems*, New Age International.
2. Yang, C.T., *Sediment Transport: Theory and Practice*, McGraw-Hill.
3. Julien, P.Y., *River Mechanics*, Cambridge University Press.
4. Jäggi, M.N.R., *Open Channel Flow with Suspended Sediment*, Springer.

CE2****A	ENVIRONMENTAL HYDRAULICS	2L: 1T: 0P	3 Credits

Module 1 Introduction to Environmental Hydraulics

Scope and relevance in water resources and environmental engineering, Governing equations for mass, momentum, and energy conservation, Classification of flow (laminar/turbulent, steady/unsteady, uniform/non-uniform), Environmental flow requirements and ecological considerations

[06]

Module 2 Mixing and Transport in Rivers and Streams

Advection and diffusion processes, One-dimensional advection-diffusion equation, Longitudinal dispersion and modelling of pollutant transport, Point and non-point source pollution in open channels

[07]

Module 3 Flow and Water Quality in Lakes and Reservoirs

Stratification and mixing processes, Temperature and density effects, Eutrophication and nutrient dynamics, Water quality modelling for lakes and reservoirs

[08]

Module 4 Urban and Stormwater Hydraulics

Urban drainage systems: design and analysis, Stormwater quality and BMPs (Best Management Practices), Green infrastructure and low-impact development, Water quality impacts of urban runoff

[08]

Module 5 Modelling and Simulation Tools

Introduction to models: QUAL2K, WASP, SWMM, Setup and calibration of water quality models, Case studies on real-world environmental hydraulics applications, Uncertainty and sensitivity analysis in environmental simulations

[09]

Total: 38 hours

References:

1) Fischer, H.B. et al., *Mixing in Inland and Coastal Waters*, Academic Press.
2) Chapra, S.C., *Surface Water-Quality Modeling,* Waveland Press.
3) Neelamani, S., Environmental Hydraulics for Open Channel Flows, Springer.
4) Thomann, R.V. and Mueller, J.A., *Principles of Surface Water Quality Modeling and Control*, Harper & Row.

CE2****A	GROUNDWATER MODELLING AND MANAGEMENT	3L: 0T: 0P	3 Credits

Module 1: Groundwater Fundamentals

Types of aquifers: confined, unconfined, semi-confined, Darcy's law and flow equations, Governing equations for 2D/3D groundwater flow, Sources of contamination and salinity intrusion

[06]

Module 2: Well Hydraulics and Aquifer Testing

Steady and unsteady flow to wells, Theis, Jacob, and Cooper-Jacob solutions, Pumping tests and determination of aquifer parameters, Step-drawdown and recovery tests

[08]

Module 3: Numerical Modelling of Groundwater Flow

Introduction to finite difference and finite element methods, Discretization techniques and grid development, Solving flow equations in MODFLOW or equivalent platforms, Model calibration, validation, and sensitivity analysis

[07]

Module 4: Contaminant Transport and Reactive Modelling

Advection, dispersion, sorption, and decay, Governing equation for solute transport, Basics of MT3DMS and RT3D for contaminant simulation, Case studies on pollution plume modelling

[07]

Module 5: Groundwater Management and Decision Support

Groundwater budgeting and sustainability, Artificial recharge and conjunctive use, Legal and policy frameworks (CGWA, CGWB, Jal Shakti Abhiyan), Decision support systems and integrated modelling tools

[08]

Total: 36 hours

References:

1. Todd, D.K., and Mays, L.W., *Groundwater Hydrology*, Wiley.
2. Anderson, M.P., and Woessner, W.W., *Applied Groundwater Modeling*, Academic Press.
3. Zheng, C. and Bennett, G.D., *Applied Contaminant Transport Modeling*, Wiley.
4. Bear, J., *Hydraulics of Groundwater*, Dover Publications.
5. NPTEL: *Groundwater Hydrology and Modeling* by Prof. V.C. Srivastava.

CE2****A	FLOOD MODELLING AND MANAGEMENT	3L: 0T: 0P	3 Credits

Module 1: Fundamentals of Flood Hydrology

Types and causes of floods: riverine, flash, urban, coastal, Hydrologic design floods and estimation of design storm, Flood frequency analysis using statistical distributions (Gumbel, Log Pearson Type III), Role of climate variability and land-use change

[08]

Module 2: Flood Routing and Forecasting

Lumped and distributed models for flood simulation, Channel routing: Muskingum, Muskingum-Cunge methods, Reservoir routing techniques, Real-time flood forecasting systems and early warning

[07]

Module 3: Hydraulic Flood Modelling Tools

One- and two-dimensional hydraulic modelling using HEC-RAS, MIKE 11, Model setup: terrain, cross-sections, boundary conditions, Calibration and validation with observed flood data, Generation of inundation maps and flood hazard zones

[07]

Module 4: Flood Risk and Vulnerability Assessment

Risk assessment frameworks and vulnerability mapping, Economic, social, and ecological consequences of floods, Flood hazard indexing and risk zoning using GIS, Case studies from Indian and international river basins

[07]

Module 5: Flood Management Strategies

Structural measures: dams, levees, channel improvements, Non-structural measures: zoning, insurance, flood proofing, Integrated flood management (IFM) and climate-resilient planning, National programs and policies: CWC, NDMA, Flood Forecasting Network

[07]

Total: 36 hours

References:

1. Subramanya, K., *Engineering Hydrology*, Tata McGraw Hill.
2. WMO, *Manual on Flood Forecasting and Warning*, WMO-No. 1072.
3. Chow, V.T., Maidment, D.R., Mays, L.W., *Applied Hydrology*, McGraw Hill.
4. Jain, S.K., and Singh, R.D., *Floods in India: Causes and Management*, World Bank Reports.
5. NPTEL: *Flood Modeling and Forecasting* by Prof. P.P. Mujumdar.

CE2****A	ADVANCED IRRIGATION SYSTEMS	3L: 0T: 0P	3 Credits

Module 1: Overview of Irrigation and Water Use Efficiency

Evolution and classification of irrigation systems, Water use efficiency and productivity in irrigation, Crop water requirements and irrigation scheduling, Precision agriculture and water-saving techniques

[10]

Module 2: Surface and Subsurface Irrigation Systems

Advanced surface irrigation methods: border, furrow, basin, Subsurface irrigation systems and automation, Design of field channels and drainage considerations, Control structures for precise water delivery

[06]

Module 3: Micro-Irrigation Systems (Drip and Sprinkler)

Design, components, and layout of drip irrigation systems, Sprinkler and mini-sprinkler systems: design and efficiency, Filtration and fertigation techniques, Performance evaluation and troubleshooting

[08]

Module 4: Irrigation System Automation and Remote Sensing Applications

Sensors and automated control systems, Soil moisture monitoring and remote scheduling, Use of drones, satellite imagery, and IoT in irrigation management, Integration with GIS for irrigation mapping

.

[06]

Module 5: Integration with GIS for irrigation mapping

Impacts of advanced irrigation on soil and groundwater, Salinity control and leaching requirements, Economics of advanced irrigation systems, Government policies, subsidy schemes (e.g., PMKSY, drip incentives)

[06]

Total: 36 hours

References:

1. Michael, A.M., *Irrigation Theory and Practice*, Vikas Publishing House.
2. Keller, J., and Bliesner, R.D., *Sprinkler and Trickle Irrigation*, Van Nostrand Reinhold.
3. Hillel, D., *Out of the Earth: Civilization and the Life of the Soil*, University of California Press.
4. ICAR Manuals on Micro-Irrigation System Design and Management
5. NPTEL: *Irrigation and Drainage Engineering* by Prof. N.T.S. Rajan.

CE2****A	WATER QUALITY AND POLLUTION CONTROL	3L: 0T: 0P	3 Credits

Module 1: Fundamentals of Water Quality

Physical, chemical, and biological characteristics of water, Standards for drinking water, irrigation, and industrial use (BIS, WHO), Classification of water bodies and water quality indices (WQI), Self-purification of streams and oxygen sag curve

[04]

Module 2: Sources and Types of Water Pollution

Point and non-point sources of pollution, Pollution from agriculture, industry, and urban areas, Eutrophication, thermal pollution, and salinity intrusion, Pathogens and emerging contaminants (pharmaceuticals, microplastics)

[10]

Module 3: Surface Water and Groundwater Quality Modelling

Mass balance and reaction kinetics, Water quality models for rivers and lakes (e.g., QUAL2K, WASP), Groundwater contamination and solute transport models (MT3DMS), Calibration, validation, and uncertainty analysis

[10]

Module 4: Pollution Control and Treatment Technologies

On-site and centralized wastewater treatment systems, Advanced water treatment: membrane filtration, adsorption, AOPs, Constructed wetlands and natural treatment systems, Pollution control measures for agriculture and industry

[06]

Module 5: Monitoring, Regulation, and Management

Water sampling techniques and laboratory analysis, Water pollution legislation in India (Water Act, EPA), Role of CPCB, SPCBs, and pollution control boards, Case studies on river basin pollution management (Ganga, Yamuna, etc.)

[06]

Total contact hours: 36

References:

1. Sawyer, C.N., McCarty, P.L., and Parkin, G.F., *Chemistry for Environmental Engineering and Science*, McGraw-Hill.
2. Peavy, H.S., Rowe, D.R., and Tchobanoglous, G., *Environmental Engineering*, McGraw-Hill.
3. Metcalf & Eddy, *Wastewater Engineering: Treatment and Reuse*, Tata McGraw-Hill.
4. CPCB Manuals and Guidelines on Water Quality and Pollution Control.
5. NPTEL: *Water and Wastewater Engineering* by Prof. Ligy Philip, IIT Madras

CE2****A	REMOTE SENSING AND GIS APPLICATIONS	3L: 0T: 0P	3 Credits

Module 1: Fundamentals of Remote Sensing

Electromagnetic spectrum and energy interaction with atmosphere and earth surface, Satellite platforms and sensors (Landsat, Sentinel, IRS, MODIS), Image characteristics: spatial, spectral, temporal, and radiometric resolution, Image acquisition, pre-processing, and enhancement

[06]

Module 2:

Visual vs. digital image interpretation, Supervised and unsupervised classification
Accuracy assessment and error matrix, Change detection and land use/land cover mapping

[06]

Module 3: GIS Fundamentals

Components and architecture of GIS, Spatial and non-spatial data: raster vs. vector models, Coordinate systems and georeferencing, Map projections and transformations

[09]

Module 4: Spatial Analysis and Modelling in GIS

Overlay, buffering, and query operations, Terrain analysis: slope, aspect, watershed delineation using DEM, Integration with hydrological models (e.g., HEC-HMS, SWAT), Network and raster-based analysis

[09]

Module 5: Applications in Water Resources Engineering

Watershed management and land use planning, Floodplain mapping and groundwater potential zoning, Urban water management and climate impact studies, Case studies using QGIS, ArcGIS, ERDAS Imagine

[08]

Total contact hours: 38

References:

1. Lillesand, T.M., Kiefer, R.W., and Chipman, J.W., *Remote Sensing and Image Interpretation*, Wiley.
2. Burrough, P.A., and McDonnell, R.A., *Principles of Geographical Information Systems*, Oxford University Press.
3. Chang, K.T., *Introduction to Geographic Information Systems*, McGraw Hill.

CE2****A	URBAN HYDROLOGY AND STORMWATER MANAGEMENT	3L: 0T: 0P	3 Credits

Module 1: Introduction to Urban Hydrology

Differences between rural and urban hydrology, Effects of urbanization on runoff, infiltration, and groundwater recharge, Urban catchment characteristics and imperviousness, Rainfall data requirements and intensity-duration-frequency (IDF) curves

[08]

Module 2: Estimation of Urban Runoff

Rational method and runoff coefficients, SCS Curve Number method for urban areas, Time of concentration and design storm selection, Use of empirical and analytical models for urban runoff prediction

[08]

Module 3: Stormwater Conveyance Systems

Design of stormwater drains, culverts, and detention/retention ponds, Hydraulic design using Manning's equation and SWMM modeling, Urban flood control and flow routing techniques, Design of stormwater inlets, manholes, and pipelines

[08]

Module 4: Best Management Practices (BMPs) and LID Techniques

Introduction to BMPs: green roofs, permeable pavements, rain gardens, Detention and retention basins, bioswales, and infiltration trenches, Low Impact Development (LID) strategies and integrated urban water management, Performance evaluation and maintenance of BMPs

Module 5: Urban Stormwater Management Policies and Applications

Urban drainage master planning and flood risk assessment, Climate change impacts on urban hydrology, Urban hydrology modelling tools (e.g., EPA SWMM, InfoWorks), Case studies of Indian and global urban water management practices

[08]

Total contact hours: 40

References:

1. Wanielista, M.P., and Yousef, Y.A., *Stormwater Management*, Wiley.
2. Butler, D., and Davies, J.W., *Urban Drainage*, CRC Press.
3. Marsalek, J., et al., *Urban Water Cycle Processes and Interactions*, IWA Publishing.

DEPARTMENT OF CIVIL ENGINEERING

SIKKIM MANIPAL INSTITUTE OF TECHNOLOGY

Minutes of the meeting of the BOS internal members held on 15/05/2025

Agenda: Framing of syllabus of M.Tech (Hydrology and Water Resources Engineering)

Members present:

1. Dr. Chandrashekhar Bhuiyan
2. Mr. Kiran Sriram (participated online)
3. Mr. Abhranil Adak

The proposed syllabus for the 2-year M.Tech degree course in Hydrology and Water Resources Engineering is of 80 credits. This syllabus will be applicable for students admitted during the academic session 2025-26 and thereafter.

The proposed syllabus has recommended six Core theory subjects, four Elective (theory) subjects, and four Lab (practical) subjects. Besides, there are Project Based Learning – I and II scheduled in the first and second semesters. The third and fourth semesters will engage students respectively, into Dissertation- Phase-I and Phase-II.

Mr. Kiran Sriram
(Member)

Mr. Abhranil Adak
(Member)

Dr. Chandrashekhar Bhuiyan
(Chairman)