NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

SCHEME OF INSTRUCTION AND SYLLABI

for M. Tech. Program in Water Resources Engineering

(Effective from 2021-22)

DEPARTMENT OF CIVIL ENGINEERING

Vision and Mission of the Institute

National Institute of Technology Warangal

VISION

Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product-oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

Vision and Mission of the Department

Department of Civil Engineering

VISION

To be a knowledge nerve centre in civil engineering education, research, entrepreneurship and industry outreach services for creating sustainable infrastructure and enhancing quality of life.

MISSION

- Generate a specialized cadre of civil engineers by imparting quality education and training.
- Attain international standards in teaching, research and consultancy with global linkages.

Department of Civil Engineering:

Brief about the Department:

The Department of Civil Engineering was established in 1959, along with the setting up of the institute, that is, REC Warangal. The Department offers undergraduate and eight postgraduate programs in addition to Ph.D. The Department has highly committed faculty who are well qualified and are members of several national and international policy making and advisory bodies, including the BIS. The Department is a recognized QIP center since 1978 to offer Ph.D. programs to faculty of other institutes. The Department is known for its cutting-edge research and believes in disseminating the knowledge through publishing in highly reputed journals and patenting the research work.

The Department maintains excellent industry-institute linkages. Most of the students are placed in reputed companies, Government organizations, and Higher Educational Institutes in India and abroad. The alumni who are important stakeholders of the Department actively guide and provide valuable inputs. They constantly peer review the syllabus and curriculum to make students industry-ready.

The Civil Engineering Department, apart from Teaching and R&D, also does an enormous amount of consultancy, which adds up to the institutional internal revenue generation and involves faculty and students in challenging field problems. There are six centers of excellence in the Department, and most laboratories have state-of-the-art equipment.

The faculty of the Department are actively involved in sponsored projects and have prestigious projects like SPARC, BRICS, IMPRINT, DST, SERB, DBT, ARDB, to name a few. The Department takes pride in having conducted the highest number of GIAN and SPARC programs.

The Civil Engineering Department has MoUs with highly reputed organizations like NAAC, NCCBM, WALAMTARI, SCCL, INVENTA, PSI, among others, and has collaborations with several foreign universities and companies such as – Texas A&M, NCAR-Colorado, PTV Group Germany, etc.

List of Programs offered by the Department:

Program	Title of the Program
B.Tech.	Civil Engineering
M.Tech.	Engineering Structures
	Water Resource Engineering
	Geotechnical Engineering
	Transportation Engineering
	Remote Sensing and Geographical Information Systems
	Environmental Engineering
	Construction Technology and Management
	Waste Management
Ph.D.	Civil Engineering

Note: **Refer to the following weblink for Rules and Regulations of M.Tech. program:**
https://www.nitw.ac.in/main/MTechProgram/rulesandregulations/

DEPARTMENT OF CIVIL ENGINEERING

M.TECH. WATER RESOURCE ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES

PEO1.	Apply knowledge of basic sciences and engineering to analyze water resources systems for socio-economic development.
PEO2.	Identify the sources of water and their characteristics.
PEO3.	Plan and design water resources systems.
PEO4.	Analyze complex field situations and provide engineering solutions for land and water management.
PEO5.	Communicate effectively, and lead multidisciplinary teams to solve water related issues with professional ethics.
PEO6.	Provide scientific inputs to decision makers.

PROGRAM ARTICULATION MATRIX:

Mission statements	PEO1	PEO2	PEO3	PEO4	PEO5	PEO6
MS1	3	3	3	3	2	2
MS2	3	3	3	3	3	3

1-Slightly; 2-Moderately; 3-Substantially

PROGRAM OUTCOMES: At the end of the program the student will be able to:

PO1	Engage in critical thinking and pursue investigations/research and development to solve practical problems.
PO2	Communicate effectively, write and present technical reports on complex engineering activities by interacting with the engineering fraternity and with society at large.
PO3	Demonstrate higher level of professional skills to tackle multidisciplinary and complex problems related to water resources engineering.
PO4	Analyse hydro meteorological data and various components of hydrological cycle and assess surface and groundwater resources.
PO5	Plan, design and operate water resources systems for meeting socio-economic and environmental needs and optimal utilization of available resources.
PO6	Develop strategies to manage hydrologic extremes and mitigate the impacts of climate change.

Mapping of Program educations objectives with program Outcomes

PEO / PO	PEO1	PEO2	PEO3	PEO4	PEO5	PEO6
PO1	**3**	**1**	**3**	**3**	**1**	**2**
PO2	**2**				**3**	**3**
PO3	**2**	**2**	**1**	**3**	**1**	**2**
PO4	**2**	**3**	**2**	**2**		
PO5	**3**	**3**	**3**	**2**	**1**	**2**
PO6	**1**	**2**	**1**	**2**	**2**	**3**

1-Slightly; 2-Moderately;3-Substantially

M.Tech (Water Resources Engineering)
Scheme of Instruction and Evaluation
(With effect from AY 2021-22)

I – Semester

S. No	Course No.	Name of the Course	L	T	P	Credits	Cat. Code
1.	CE5701	Applied Hydrology	3	0	0	3	PCC
2.	CE5702	Advanced Fluid Mechanics	3	0	0	3	PCC
3.	CE5703	Computational Methods in Water Resources Engineering	3	0	0	3	PCC
4.	CE5704	Stochastic Hydrology	3	0	0	3	PCC
5.		Elective – I	3	0	0	3	PEC
6.		Elective – II	3	0	0	3	PEC
7.	CE5705	Geographic Information Systems (GIS) Applications Lab	0	1	2	2	PCC
8.	CE5706	Computational Lab	0	1	2	2	PCC
9.	CE5748	Seminar – I	0	0	2	1	SEM
		TOTAL	18	2	6	23	

II – Semester

S. No	Course No.	Name of the Course	L	T	P	Credits	Cat. Code
1.	CE5751	Water Resources Systems Planning and Management	3	0	0	3	PCC
2.	CE5752	Groundwater Modelling	3	0	0	3	PCC
3.		Elective - III	3	0	0	3	PEC
4.		Elective – IV	3	0	0	3	PEC
5.		Elective – V	3	0	0	3	PEC
6.		Elective – VI	3	0	0	3	PEC
7.	CE5753	Water Resources Systems Design Lab	0	1	2	2	PCC
8.	CE5754	Hydrologic and Hydraulic Modelling Lab	0	1	2	2	PCC
9.	CE5798	Seminar – II	0	0	2	1	SEM
		TOTAL	18	2	6	23	

III – Semester

S. No	Course No.	Name of the Course	L	T	P	Credits	Cat. Code
1.		Industrial Training (8-10 weeks; Optional)	-	-	-		
2.	CE6747	Comprehensive Viva Voce	-	-	-	2	CVV
3.	CE6749	Dissertation Part - A	-	-	-	12	DW
		TOTAL	-	-	-	14	

IV – Semester

S. No	Course No.	Name of the Course	L	T	P	Credits	Cat. Code
1.	CE6799	Dissertation Part - B	-	-	-	20	DW
		TOTAL	-	-	-	20	

Credits in Each Semester					
Cat. Code	**Sem-I**	**Sem-II**	**Sem-III**	**Sem-IV**	**Total**
PCC	16	10	0	0	26
PEC	6	12	0	0	18
SEM	1	1	0	0	02
CVV	0	0	2	0	02
DW			12	20	32
Total	**23**	**23**	**14**	**20**	**80**

Abbreviations:

PCC – Program Core Courses
PEC – Program Elective Courses
SEM – Seminar
CVV – Comprehensive Viva Voce
DW – Dissertation Work

Program Elective Courses

Elective – I, II (I Year, I Semester)		
S. No.	**Course Code**	**Course**
1.	CE5711	Design of Hydraulic Structures
2.	CE5712	Design of Water Supply and Sewerage Systems
3.	CE5713	Integrated Watershed Management
4.	CE5714	Land and Water Management
Elective – III, IV, V, VI (I Year, II Semester)		
S. No.	**Course Code**	**Course**
1.	CE5761	Free Surface Flow
2.	CE5762	Urban Water Management
3.	CE5763	Climate and Climate Change Modelling
4.	CE5764	Advanced Hydrologic Modelling
5.	CE5765	Applications of Soft Computing Techniques
6.	CE5766	Fluvial Hydraulics
7.	CE5767	Hydropower Systems
8.	CE5768	Applications of Remote Sensing & GIS in Water Resources & Environmental Engineering

Note: In addition to the above elective courses, students can take elective courses from other specializations offered by the respective M. Tech programs in the department.

DETAILED SYLLABUS

M.Tech. – Water Resources Engineering

Course Code: CE5701	APPLIED HYDROLOGY	Credits 3-0-0: 3

Pre-Requisites: NONE

Course Outcomes: At the end of the course, the student will be able to

CO1	Analyse components of hydrologic cycle
CO2	Predict hydrologic extreme events for hydraulic and hydrologic design
CO3	Develop forecasting models for operation of hydrologic systems
CO4	Assess surface water resources

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		2	3		1
CO2	1		2	3	1	3
CO3	1		3	3		2
CO4	1		2	3		1

Syllabus:

Introduction: Description of Hydrologic Cycle, Overview of application of hydrology in engineering, Historical aspects of development of hydrology, Eco-hydrology

Precipitation: Characteristics of precipitation in India, Measurement of precipitation, rain gauge network, collection and presentation of rainfall data, analysis of rainfall data, intensity-duration-frequency analysis and depth-area-duration analysis, development of design storms for typical regions in data scarce environment

Abstractions from Precipitations: Evaporation and Evaporation Process, measurement, estimation and control of evaporation, Evapotranspiration, measurement and estimation of evapotranspiration, interception and depression storage, Infiltration process, measurement of infiltration, infiltration models and infiltration indices and effective rainfall, Core of Engineers Procedure for developing effective rainfall hyetograph

Stream flow Measurement: Streamflow measurement, stage-discharge relationship and rating curve, Runoff characteristics, catchment characteristics affecting the runoff, yield from a catchment, flow duration curve and flow mass curve

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 - 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

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

Learning Resources:

Text Books:

1. Applied Hydrology, Chow, V.T., Maidment, D.R., and Mays, L.W., Tata McGraw Hill Edition, 2017 2nd Edition
2. Engineering Hydrology, Subramanya, K., Tata McGraw Hill Publications, 2017 4th Edition
3. Hydrologic Analysis and Design, McCuen, R.H., Pearson Publications, 2017 4th Edition

Reference Books:

1. Water Resources Engineering, Mays, L.W., Wiley Publications, 2019 3rd Edition
2. Introduction to Hydrology, Viessman, W., and Lewis, G.L., Prentice Hall of India, 2008 5th Edition

Online Resources:

1. https://nptel.ac.in/courses/105/104/105104029/

Course Code: CE 5702	ADVANCED FLUID MECHANICS	Credits 3-0-0: 3

Pre-Requisites: NONE

Course Outcomes: At the end of the course, the student will be able to

CO1	Formulate momentum, energy and mass transport models
CO2	Analyze Potential Flows
CO3	Develop approximate solutions for small and large Reynolds number flows
CO4	Apply turbulent flow models

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		3	1		
CO2	1		3	2		
CO3	2		3	2	1	
CO4	2		3	1	1	

Syllabus:

Review of physical meaning of mathematics necessary for understanding of fluid mechanics, review of analogies in mass transfer and heat transfer.

Description of fluid flow: with reference to translation, rotation and deformation concept of continuum, control mass & control volume approach, Reynolds transport theorem. Steady flow and uniform flow.

Velocity field, one & two-dimensional flow analysis, circulation and vorticity, stream function and velocity potential function, potential flow, standard flow patterns, combination of flow patterns, flow net.

Dimensional Analysis as a tool in design of experiments, identification of non-dimensional numbers and their significance, dimensional analysis methods.

Equations of motion for laminar flow of a Newtonian fluid - Viscous flow – Navier-Stoke's equations, simple exact solutions.

Boundary Layer Theory-Formation, growth and separation of boundary layer-Integral momentum principles to compute drag and lift forces-Mathematical models for boundary layer flows.

Turbulence, Origin of turbulence, universal velocity distribution laws of turbulence, smooth rough and transitional turbulent flow in pipes, pipe resistance equation for pipes design of pipe networks, Diffusion and dispersion of pollutants in natural streams.

Learning Resources:

Text Books:

1. Fluid Mechanics, Fox, R.W., Pitchard, P.J., and Mcdonald, A.T.,Wiley India Pvt. Ltd., 2009.
2. Boundary Layer Theory,Schlichting, H., and Gresten, K.,Springer Publications, 2004.
3. Viscous Fluid Flow,White, F.M.,McGraw Hill Pub. Co, New York, 2011.

4. Theory of Hydraulic Models, Yalin, M.S., McMillan Co., 1971

Reference Books:

1. Fluid Mechanics, Streeter V.L., McGraw Hill Book Co., New Delhi, 1999.
2. An Introduction to Fluid Mechanics, Chung Fang, Springer International Publishing, 2018.

Online Resources:

1. https://nptel.ac.in/courses/112/105/112105218/
2. https://nptel.ac.in/courses/112/105/112105287/

Course Code: CE 5703	COMPUTATIONAL METHODS IN WATER RESOURCES ENGINEERING	Credits 3-0-0: 3

Pre-Requisites: NONE

Course Outcomes: At the end of the course, the student will be able to

CO1	Apply numerical methods for solution of differential equations in Water Resources and Environmental Engineering
CO2	Apply finite difference schemes for solution of hydraulic and hydrologic models
CO3	Apply method of characteristics for hydraulic transients in pipes and channels
CO4	Formulate finite element model for solution of flow through porous media

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2		3	1	2	
CO2	2		3	2	2	
CO3	2		3	2	2	1
CO4	2		3	3	1	1

Syllabus:

Overview of the course, the need for computational and statistical methods, overview of the applications in Civil Engineering in general and Water Resources and Environmental Engineering in particular.

Review of numerical techniques for finding roots of non-linear equations and numerical integration.

Ordinary differential equations, nature of problems, boundary and initial equations, Euler's method, modified Euler's method, Predictor-Corrector methods, Runge-Kutta methods, Boundary value problems, Applications for reservoir routing, gradually varied flow problems, pipe networks.

Partial differential equations, classification, nature of problems, Concepts of finite difference method, finite difference schemes, Solution of parabolic equations, pollutant transport, Solution of elliptical equations, solution of Laplace equation and Poisson equation, flow through porous media, Solution of hyperbolic equation, method of characteristics, unsteady flow through open channels, propagation of waves, Concepts of finite volume method.

Basic concepts of Finite Element Method, FEM vs FDM, Element shapes, shape functions, development of shape functions for linear elements, Formulation of FEM for stress analysis problems, flow through porous media, Galerkin's method and Variational method for formulation of stiffness matrix.

Learning Resources:

Text Books:

1. Numerical Methods for Engineers and Scientists, Hoffman, J.D., CRC Press, Special Indian Edition, 2011
2. Statistics, Probability and Reliability for Civil and Environmental Engineers, Kotteguda, N.T. and Renzo Resso, McGraw Hill Companies Inc., New York, 1998

3. Applied Numerical Methods for Engineering, Schilling, R.J., and S.L. Harris, CENGAGE Learning, India Edition, 2007
4. Computational Hydraulics,Abbot, M.A. and Vervey, Elsevier Publications, 1996

Reference Books:

1. The Finite Volume Method in Computational Fluid Dynamics, Moukalled, F., Mangani, L., Darwish, M., Springer International Publishing, 2015.

Online Resources:

1. https://nptel.ac.in/courses/112/105/112105045/

Course Code: CE5704	STOCHASTIC HYDROLOGY	Credits 3-0-0: 3

Pre-Requisites: NONE

Course Outcomes: At the end of the course, the student will be able to

CO1	Analyse hydrologic data
CO2	Perform frequency analysis of hydrologic extremes
CO3	Apply multivariate analysis in hydrologic systems
CO4	Analyse hydrologic time series
CO5	Develop models for synthesis of hydrologic variables

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		2	3		1
CO2	1		2	3		3
CO3	1		3	3	1	1
CO4	1		3	3		2
CO5	2		3	3	1	2

Syllabus:

Deterministic and Stochastic Hydrology, review of concepts of probability, probability axioms, Random variables and their properties, probability distribution and probability density function.

Discrete and continuous probability distributions used in hydrology, moments and expectations of distributions, Parameter estimation, method of moments, maximum likelihood method and method of probability weighted moments.

Hypothesis testing, goodness test of fit tests, Chi Square test and KS test.

Frequency analysis of hydroclimatic extremes, extreme value distributions, analysis of floods, droughts and other natural hazards, Regional flood frequency analysis, Risk and reliability in hydrologic design, Analysis and measures of hydrologic uncertainty.

Correlation analysis and correlation coefficient, Simple linear regression, Multivariate regression analysis, Correlation coefficient and its significance in regional analysis, analysis of variance, applications – rainfall-runoff analysis, rating curves, water quality modelling, Multivariate analysis, principal component analysis, cluster analysis.

Hydrologic Time Series Analysis, Hydrologic time series, stationary and non-stationary time series, Ensemble and realisation, trend analysis, trend removal, analysis of periodicity, Fourier transformation and harmonic analysis, autocorrelation function, spectral density function, Wavelet analysis.

Modelling of Hydrologic Time Series, Time series models, autoregressive and moving average models, periodic models, Calibration and validation of hydrologic time series models, data generation techniques, simulation of hydrologic time series, streamflow

forecasting, First order Markov process, Markov chain, Multi-site time series model, cross-correlation, spatial and temporal disaggregation models.

Theory of copula and its use in hydrology, commonly used copula functions, selection of best fit copula, uses of copula.

Learning Resources:

Text Books:

1. Statistical Methods in Hydrology, Haan T. C., East West Publishers, 2002
2. Statistics, Probability and Reliability for Civil and Environmental Engineers, Kotteguda, N.T., and Resso, R., Blackwell Publishing, UK, 2008

Reference Books:

1. Stochastic Water Resources Technology, Kotteguda, N.T., The Macmillan Press, New York, 1982
2. Statistical Methods in Hydrology and Hydroclimatology, Rajib Maity, Springer Nature Singapore Pte Ltd., 2018

Online Resources:

1. https://nptel.ac.in/courses/105/108/105108079/

Course Code: CE5705	GEOGRAPHICAL INFORMATION SYSTEMS APPLICATIONS LABORATORY	Credits 0-1-2: 2

Pre-Requisites: NONE

Course Outcomes: At the end of the course, the student will be able to

CO1	Prepare the different geospatial layers
CO2	Compute geometric measurements and perform spatial analysis
CO3	Create high-quality maps and associated graphics
CO4	Integrate different geospatial layers

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	2		
CO2	1	2	3	3		1
CO3	1	2	3	3		
CO4	1	2	3	2		

Syllabus:

Importing maps and layers from various sources
Accessing various online data resources for water resources applications
Georeferencing and projection
Digitization of Points and Lines
Editing Map Elements
Attribute Data Entry and Manipulation
Cleaning, Building and Transformation
Data Analysis – Overlay, Buffer
Map Generation with Patterns and Legends
Buffer Analysis
Network Analysis
Watershed delineation and Geomorphologic characteristics of watershed
Supervised and unsupervised classification of remote sensed data

Learning Resources:

Text Books:
1. ArcGIS user manuals
2. QGIS User Manuals

Online Resources:
1. https://docs.qgis.org/2.8/en/docs/training_manual/processing/hydro.html
2. https://hatarilabs.com/ih-en/watershed-and-stream-network-delineation-on-large-scale-basins-with-qgis-3-tutorial
3. https://support.esri.com/en/technical-article/000012346

Course Code: CE5706	COMPUTATIONAL LABORATORY	Credits 0-1-2: 2

Pre-Requisites: NONE

Course Outcomes:

At the end of the course, the student will be able to

CO1	Perform statistical analysis of hydrologic data
CO2	Analyse hydrologic time series and develop hydrologic time series models
CO3	Analyse and design water distribution networks
CO4	Apply numerical methods for computation of backwater profile, hydraulic flood routing
CO5	Use software tools like R and MATLAB for hydraulic and hydrologic design

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	2	3		1
CO2	1	2	3	3		1
CO3	2	2	3	1	3	1
CO4	2	2	3	2	2	2
CO5	3	2	3	3	3	3

Syllabus:

Introduction to Programming and Algorithms, Basic concepts and syntaxes of R, Python and MATLAB.

Using R/MATLAB for statistical analysis, frequency analysis of hydrologic extremes, time series analysis and modelling.

Reservoir flood routing modules using R/MATLAB.

Apply finite difference methods for hydraulic flood routing.

Learning Resources:

Online Resources:

1. https://rstudio-education.github.io/hopr/
2. https://in.mathworks.com/help/matlab/

Course Code: CE5748	SEMINAR – I	Credits 0-0-2: 1

Course Outcomes: At the end of the course, the student will be able to

CO1	Identify and choose appropriate topic of relevance
CO2	Assimilate literature on technical articles of specified topic
CO3	Write technical report
CO4	Present a technical talk on the chosen topic

CO-PO mapping:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2			
CO2	3	1	3			
CO3	2	3	3			
CO4	2	2	2			

Syllabus:

There is no specific syllabus for this course. Student can choose any topic, of his choice, pertaining to Hydrology and Water Resources Engineering. Topic should be a relevant and currently researched one. Students are advised to refer articles published in current journals in the area of Hydrology and Water Resources Engineering for choosing their seminar topics. Student should review minimum of 10 to 15 research papers relevant to the topic chosen, in addition to standard textbooks, codebooks, etc. Students are required to prepare a seminar report, in the standard format and give presentation to the Seminar Assessment Committee (SAC) in the presence of their classmates. It is mandatory for all the students to attend the presentations of their classmates

Learning Resources:

1. SCI/ Scopus indexed journals in Hydrology and Water Resources Engineering
2. Research articles and reports published by various national and international research organizations

Course Code: CE5751	WATER RESOURCECS SYSTEMS PLANNING & MANAGEMENT	Credits 3-0-0: 3

Pre-Requisites: CE5701, CE5704

Course Outcomes: At the end of the course, the student will be able to

CO1	Apply concepts of systems analysis for planning of water resources systems
CO2	Perform basic economic analysis to evaluate the economic feasibility of water resources and environmental engineering projects
CO3	Formulate and solve deterministic optimization models for design and operation of water resources systems
CO4	Formulate and solve stochastic and fuzzy optimization problems for decision making under uncertainty

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		3	1	3	1
CO2	1		3		3	
CO3	2		3		3	3
CO4	2		3		3	3

Syllabus:

Overview of the course, concepts of systems analysis, water resources planning, Modeling techniques, objectives and constraints, overview of optimization techniques.

Linear programming, graphical method, simplex method, sensitivity analysis, duality.

Dynamic programming, concepts, formulation of recursive equation.

Classical optimization techniques, Lagrange methods, Kuhn-Tucker conditions, Search techniques,

Stochastic optimization techniques, chance constrained LP, stochastic dynamic programming, decision making under uncertainty, fuzzy optimization.

Overview of multi objective optimization, multi criteria decision making, Simulation-optimizations.

Overview of Genetic Algorithm and other evolutionary algorithms

Economic analysis, discounting techniques, benefit cost evaluation.

River basin modelling, storage-yield relation, reservoir design and operation.

Overview of applications of optimization and simulation techniques in hydrologic and water resources systems – irrigation management, water quality management, groundwater management, water conveyance and distribution systems.

Learning Resources:

Text Books:

1. Water Resources Systems Planning and Management – An introduction to methods, models and applications, Loucks, D.P. and Eelco van Beek, UNESCO and Springer, 2017

2. Water Resources Systems Modeling Techniques and Analysis, Vedula, S. and Mujumdar, P.P., Tata McGraw Hill Pub. Co., 2005

Reference Books:

1. Water Resources Systems Planning and Analysis, Loucks, D.P., Stedinger, J.R. and Haith, D.A., Prentice Hall Inc., 1982
2. Civil and Environmental Systems Engineering, Charles, S.R., Whitlatch, E.E., and Wright, J.R., Pearson Education Inc., 2004

Online Resources:

1. https://nptel.ac.in/courses/105/108/105108130/

Course Code: CE5752	GROUNDWATER MODELLING	Credits 3-0-0: 3

Pre-Requisites: CE5701

Course Outcomes: At the end of the course, the student will be able to

CO1	Assess groundwater flow and model regional groundwater flow
CO2	Identify of groundwater source by groundwater prospecting
CO3	Design water wells
CO4	Manage groundwater resources
CO5	Plan and design artificial recharge systems

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		3	3		1
CO2	1		3	3		1
CO3	2		3	1	3	2
CO4	2		3	1	3	2

Syllabus:

Introduction to Groundwater: Ground water availability, Groundwater in the hydrologic system, Hydrologic budget, Vertical distribution of subsurface strata, Types of aquifers, Aquifer characteristics.

Groundwater Movement: Darcy's law, Hydraulic conductivity and intrinsic permeability, Transmissivity, Homogeneity and isotropy, Stream function, Flownet

Groundwater Flow Hydraulics:Well hydraulics, partial differential equations governing groundwater flow in aquifers estimation of aquifer parameters by different methods, steady groundwater flow analysis for multiwall systems, Well flow near different boundary conditions, Method of images

Groundwater Modelling: Groundwater modelling, formulation of anisotropic and non-homogenous flow of groundwater, finite difference methods for solving groundwater flow problems, regional groundwater flow modelling

Groundwater Prospecting: Geologic method, Remote sensing, Geophysical exploration, Electric resistivity method, Seismic method, Gravity and magnetic methods

Well Logging and Construction: Type of wells, Selection of well site, Well logging, Well construction techniques, Well completion

Groundwater Management: Concept of basin management, Conjunctive use of surface water and groundwater, Groundwater management techniques

Managed Groundwater Recharge: Objective and purpose of MGR, Methods of MGR

Climate Change Impacts on Groundwater: Hydrological components affecting the groundwater, Direct impacts of climate change on groundwater, Indirect impacts of climate change on groundwater, Climate change impacts on water availability in an aquifer

Learning Resources:

Text Books:

1. Groundwater Hydrology: Engineering, Planning and Management, Karamouz, M., Ahmadi, A., and Akhbari, M., CRC Press, Taylor et Francis Group, 2020
2. Groundwater Hydrology, Todd, D. K., and Mays, L. W., John Wiley & Sons, Singapore, 2018
3. Numerical Groundwater Hydrology, Rastogi, A.K., Penram International Publishing Pvt. Ltd., 2012

Reference Books:

1. Hydrogeology, Davis, S. N., and De Weist, R. J. M., John Wiley & Sons, New York, 2013
2. Groundwater Hydrology, Chahar, B. R., McGraw Hill Education (India) Private Limited, New Delhi, 2015

Online Resources:

1. https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2002WR001516
2. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/groundwater-management
3. https://www.usgs.gov/mission-areas/water-resources/science/artificial-groundwater-recharge

Course Code: CE5753	WATER RESOURCES SYSTEMS DESIGN LABORATORY	Credits 0-1-2: 2

Pre-Requisites: CE5701, CE5704

Course Outcomes: At the end of the course, the student will be able to

CO1	Develop storage-yield-reliability relationship for a reservoir & optimal operating policy of a reservoir
CO2	Simulate and evaluate the performance of a reservoir
CO3	Plan and develop an irrigation system
CO4	Develop optimal policy for water quality management in a river

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	2	2	3	1
CO2	1	1	2	2	2	1
CO3	2	2	3	1	3	1
CO4	2	2	3	1	3	2

Syllabus:

Determining storage capacity of a reservoir, Development of storage-yield-reliability relationship for a reservoir, Developing optimal operating policy for a single and multi-reservoir system

Crop planning and irrigation scheduling, Water quality management in a river

Optimal design of water distribution networks, Simulation of operation of a reservoir,

Simulation of an aquifer, Performance evaluation of an irrigation system

Demonstration of the applications of Genetic algorithm and other evolutionary algorithms.

Learning Resources:

Text Books:

1. Water Resources Systems Planning and Management – An introduction to methods, models and applications, Studies and Reports in Hydrology, Loucks, D. P., and Eelco van Beek UNESCO Publishing, 2005
2. Civil and Environmental Systems Engineering, Revelle, S.C., Whitlatch, E. E., and Wright, R. J., Pearson Education Inc., New Jersey, 2004

Reference Books:

1. Water Resources Systems Modeling Techniques and Analysis, Vedula, S., and Mujumdar, P.P., Tata McGraw Hill Pub. Co., New Delhi, 2005
2. Water Resource Systems Planning and Management: An Introduction to Methods, Models, and Applications, Daniel P. Loucks and Eelco van Beek, Springer International Publishing, 2018

Online Resources:

1. https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/irrigation-scheduling
2. https://pubs.usgs.gov/wri/wri974228/text/simshallow.htm

Course Code: CE5754	HYDROLOGIC AND HYDRAULIC MODELLING LAB	Credits 0-1-2: 2

Pre-Requisites: CE5701, CE5702

Course Outcomes: At the end of the course, the student will be able to

CO1	Compare and comprehend different hydrologic and hydraulic models
CO2	Utilize hydrological models such as SWAT and HEC-HMS for hydrological analysis
CO3	Make use of hydraulic models for analysis of water distribution and drainage networks
CO4	Apply hydrologic and hydraulic models for design of urban water systems

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		2	1	1	
CO2	2	1	3	2		1
CO3	2	1	3	2	1	1
CO4	2	1	3		3	2

Syllabus:

Design and analysis of water distribution networks using EPANET; Downloading and using data from various open sources, Event based flood modelling using HEC-HMS, Continuous simulation modelling using SWAT; Flood inundation mapping using HEC-RAS; Design and analysis of storm water drainage network using SWMM

Learning Resources:

Reference Books:

1. HEC-HMS: Hydrologic Engineering Centres- Hydrologic Modelling System http://www.hec.usace.army.mil/software/hec-hms/
2. HEC-RAS: Hydrologic Engineering Centres River Analysis System http://www.hec.usace.army.mil/software/hec-ras/
3. SWMM: Storm Water Management Model http://www2.epa.gov/water-research/storm-water-management-model-swmm
4. SWAT: Soil and Water Assessment Tool http://swat.tamu.edu/
5. EPANET: Hydraulic modelling of water distribution piping system http://www2.epa.gov/water-research/epanet

Online Resources:

1. https://web.ics.purdue.edu/~vmerwade/tutorial.html

Course Code: CE5798	SEMINAR – II	Credits 0-0-2: 1

Course Outcomes: At the end of the course, the student will be able to

CO1	Identify and choose appropriate topic of relevance
CO2	Assimilate literature on technical articles of specified topic
CO3	Write technical report
CO4	Present a technical talk on the chosen topic

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2			
CO2	3	1	3			
CO3	2	3	3			
CO4	2	2	2			

Syllabus:

There is no specific syllabus for this course. Student can choose any topic, of his choice, pertaining to Hydrology and Water Resources Engineering. Topic should be a relevant and currently researched one. Students are advised to refer articles published in current journals in the area of Hydrology and Water Resources Engineering for choosing their seminar topics. Student should review minimum of 10 to 15 research papers relevant to the topic chosen, in addition to standard textbooks, codebooks, etc. Students are required to prepare a seminar report, in the standard format and give presentation to the Seminar Assessment Committee (SAC) in the presence of their classmates. It is mandatory for all the students to attend the presentations of their classmates

Learning Resources:

1. SCI/ Scopus indexed journals in Hydrology and Water Resources Engineering
2. Research articles and reports published by various national and international research organizations

Course Code: CE 5711	DESIGN OF HYDRAULIC STRUCTURES	Credits 3-0-0: 3

Pre-Requisites: NONE

Course Outcomes: At the end of the course, the student will be able to

CO1	Analyse and design earth and rockfill dams
CO2	Analyse and design gravity dams
CO3	Design spillways and energy dissipation structures
CO4	Explain the principles of hydraulic modeling

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		2	2	3	
CO2	1		3	2	3	
CO3	1		3	1	3	2
CO4	1		2		3	

Syllabus:

Introduction: Hydraulic structures for water resources projects. Types of hydraulic structures, storage, diversion, conveyance and distribution structures, capacity of a reservoir, reservoir silting, types of dams

Hydraulic structures on permeable foundations, seepage theories, Khosla's theory, design of diversion headworks and other structures on permeable foundations

Embankment Dams: Types, design considerations, seepage analysis and control, stability analysis, construction techniques.

Gravity Dams: Forces acting on failure of a gravity dam, stress analysis, elementary profile, design of gravity dam, other functional features of a gravity dam.

Dam Outlet Works: Types of outlet structures, ogee spillway, chute spillway, siphon spillway, side channel spillway, Labyrinth and Piano-key weir.

Terminal Structures: Hydraulic jump types, stilling basin, roller bucket, ski jump basin, baffled spillway, drop structure

Hydraulic Modeling: Basic principles, dimensional analysis, modelling free-surface flows, design of physical models.

Learning Resources:

Text Books:

1. Irrigation, Water Power and Hydropower Engineering, Arora K. R., Standard Book Publishing, New Delhi, 5th Edition, 2018
2. Irrigation Water Resources and Hydropower Engineering, Modi, P. M., Standard Book Publishing Company, New Delhi, 9th Edition, 2014
3. Hydraulic Structures, Novak, P. and Nalluri, C., Taylor & Francis. 2007Edition 4.
4. Irrigation and Water Resources Engineering, Asawa G.L., New Age International Publishers, New Delhi, 2006

5. Embankment Dam and Engineering, Singh, B., and Varshney, R.S., Nem Chand and Brothers. 2004.
6. Earth and Rockfill Dams, Bharath Singh and Sharma, H. D., Saritha Prakashan, 1976.

Reference Books:

1. Water Resources Engineering – Principles and Practice, Murthy, C.S.N., New Age International Publishers, New Delhi, 20202nd Edition
2. Concrete Dams, Sharma, H.D., CBIP Publication, 1998.
3. Hydraulic Design of Stilling Basins and Energy Dissipators, Peterka, A.J, USBR Engineering Monographs No. 25". 1984

Online Resources:

1. https://www.routledge.com/IAHR-Design-Manual/book-series/TFIAHRHSDM

Course Code:CE5712	DESIGN OF WATER SUPPLY AND SEWERAGE SYSTEMS	Credits 3-0-0: 3

Pre-Requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Comprehend the need of Water supply and sewage systems
CO2	Design of water transmission and optimization of water distribution networks
CO3	Interpret the processes involved in secondary wastewater treatment systems.
CO4	Assimilate the Principles of sludge treatment and disposal methods.

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		1	1	2	-
CO2	2		2	1	3	-
CO3	2		2	1	3	1
CO4	2		2	1	3	2

Syllabus**:**

Sources of water and water quality- Planning of water supply systems, Selection of water treatment trains, Transportation of water; Appurtenances for water transmission; Selection of pipe materials, Jointing, Laying and Maintenance, Water distribution pipe networks- Design, analysis and optimization, Water hammer analysis; –Corrosion prevention – Minimization of water losses – Leak detection- SCADA systems- Specific contaminant removal systems.

Wastewater Sources and flow rates, Collection, Characteristics, Standards of Disposal, Treatment Objective and Strategies, Sewage collection systems; Sanitary sewer design, Biological Treatment Processes: Types, low cost sanitation systems; Treated wastewater reuse/recycle.

Water treatment residuals and Wastewater sludge management and disposal. Use of computer software in water transmission, water distribution, wastewater collection.

Learning Resources:

Text books:

1. Water and Wastewater Engineering: Design Principles and Practice, Mackenzie L. Davis, McGraw Hill, 2010.
2. *Wastewater Engineering – Collection, Treatment, Disposal and Reuse*, Metcalf and Eddy, 5th Ed., McGraw Hill Pub. Co., 2014
3. Environmental Engineering, Howard S. Peavy, Donald R. Rowe and George Tchobanoglous, McGraw Hill., 2017

Reference Books:

1. Water Supply and Wastewater Removal, Nazih K. Shammas, Lawrence K. Wang, 3rd Edition, John Wiley & Sons, Inc, 2011
2. WATER QUALITY& TREATMENT, AWWA Hand book, McGraw Hill, 2011.
3. Urban Water Supply Handbook, Larry W. Mays, McGraw Hill, 2002.

4. CPHEEO, Manual on Water Supply and Treatment, 3rd Ed., Ministry of Urban Development, New Delhi, May 1999.
5. CPHEEO, Manual on Operation and Maintenance of Water Supply Systems, Ministry of Urban Development, New Delhi, January 2005.
6. CPHEEO, Manual on Sewerage and Sewage Treatment, 3rd Ed., Ministry of Urban Development, New Delhi, November 2013.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc20_ce23/preview
2. https://ocw.mit.edu/courses/urban-studies-and-planning/11-479j-water-and-sanitation-infrastructure-in-developing-countries-spring-2007/readings/hwts_paper.pdf
3. http://www.who.int/water_sanitation_health/dwq/WSH02.07.pdf
4. https://nptel.ac.in/courses/105/105/105105178/
5. https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-85-water-and-wastewater-treatment-engineering-spring-2006/lecture-notes/
6. https://onlinecourses.nptel.ac.in/noc21_ce25/preview

Course Code: CE5713	INTEGRATED WATERSHED MANAGEMENT	Credits 3-0-0: 3

Pre-Requisites: NONE

Course Outcomes: At the end of the course, the student will be able to

CO1	Classify and Prioritize Watersheds for Watershed Management
CO2	Plan and design soil conservation measures in a watershed
CO3	Plan and design water harvesting and groundwater recharge structures
CO4	Plan measures for reclamation of saline soils

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		2	2	1	1
CO2	2		3	1	3	2
CO3	2		3	1	3	2
CO4	2		3	1	3	2

Syllabus:

Introduction to Watershed and Watershed Management, Problems and Prospects in Watershed Management, History of Watershed Management in India, Land classification and Watershed based land use planning, Planning for Watershed Management, Participatory watershed management

Watershed Characteristics: Physical and Geomorphologic Factors affecting Watershed Management, Watershed Characteristics: Classification and Measurement, Importance of Watershed Properties for Watershed Management, Prioritizations of Watersheds.

Hydrology in soil and water conservation, Hydrologic Data for Watershed Planning, Rainfall-Runoff relationships, Water Yield Assessment and Measurement from Watersheds.

Principles of soil erosion, Soil Erosion Mechanism, Estimation of soil loss from small watersheds, Measurements and Estimation of Sediment Yield, Soil Erosion Control Measures – Engineering and Agronomical.

Water Harvesting Concepts and Methods, Principles of water harvesting, methods of rainwater harvesting, Rainwater Conservation Technologies and Water Harvesting Structures, Farm Ponds, Earthen Dams, Artificial recharge of groundwater in small watersheds, methods of artificial recharge.

Salt Problems in Soil and Water, Classification of Salt Affected Soils, Reclamation of Saline Soils.

Learning Resources:

Text Books:

1. Watershed Management, Murthy, J.V.S., New Age International Publishers, 2017 2nd Edition
2. Land and Water Management, Murthy, V.V.N., and Jha, M.K., Kalyani Publishers, 2013 6th Edition

Reference Books:

1. Soil and Water Conservation Engineering, Suresh, R., Standard Publishers, 1998
2. Water Resources Conservation and Management, Chatterjee, S.N., Atlantic Publishers, 2008
3. Common Guidelines for Watershed Development Projects, Government of India, 2008

Online Resources:

1. https://nptel.ac.in/courses/105/101/105101010/
2. http://ecoursesonline.iasri.res.in/course/view.php?id=542

Course Code: CE5714	LAND AND WATER MANAGEMENT	Credits 3-0-0: 3

Pre-Requisites: NONE

Course Outcomes: At the end of the course, the student will be able to

CO1	Plan irrigation systems and command area development programs
CO2	Evaluate performance of an irrigation system
CO3	Plan measures for reclamation of waterlogged lands
CO4	Develop strategies for conflict management in irrigation projects

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		2	1	3	1
CO2	1		3	1	3	1
CO3	1		3	1	3	1
CO4	1		3	1	3	2

Syllabus:

Introduction – Need for proper management of land and water resources.

Planning of irrigation projects – Inadequacies in present approaches in canal irrigation management – command area development programs.

Classification of irrigable soils – soils-plant-water relationships – soil management Irrigation management – Irrigation Management Matrix – Society and irrigation – perceptions of various stake holders on irrigation system performance

Macro and precision irrigation, Diagnostic analysis of irrigation systems – performance indicators for performance evaluation of irrigation projects

Water logging and salinity – water quality for irrigation

Participatory irrigation management – Farmer's management of irrigation system acts - conflict resolution

Legal aspects in water sharing and management – PC-CP - case studies

Learning Resources:

Text Books:

1. Irrigation Water Management, Majumdar, D.K., Prentice Hall of India, New Delhi, 2013, 2nd Ed.
2. Irrigation: Theory and Practice, Michael, A.M., Vikas Publishing House Pvt. Ltd. New Delhi, 2009

Reference Books:

1. Land and Water Management Engineering, Murthy, V.V.N., Kalyani Publishers, Ludhiana, 2011
2. Soil and Water Management Systems, Scwabe, G.O., Fangmeir, D.D., and Elliot W.J., John Wiley and Sons, N York, 1996

Online Resources:

1. https://www.iima.ac.in/c/document_library/4ParticipatoryIrrigation8f9a.pdf?uuid=a5eced82-3f75-4068-9aa1-57aef9de0876&groupId=62390
2. https://www.iwapublishing.com/news/integrated-water-resources-management-basic-concepts
3. https://www.indiawaterportal.org/articles/introduction-integrated-water-resource-management-iwrm-open-courseware-united-nations

Course Code: CE 5761	FREE SURFACE FLOW	Credits 3-0-0: 3

Pre-Requisites: NONE

Course Outcomes: At the end of the course, the student will be able to

CO1	Compute flow profiles in channel transitions and due to hydraulic structures
CO2	Design channels including irrigation canals and storm water drains
CO3	Formulate and solve the problem of propagation of flood wave and surges in channels
CO4	Formulate and solve hydraulic flood routing models

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		2	2		
CO2	1		2		3	1
CO3	2		3		2	2
CO4	2		3		2	2

Syllabus:

Uniform Flow in Open Channels& Compound Channels, Specific energy, Critical flow, Channel transitions, Uniform flow formulae, Best hydraulic sections.

Steady Gradually Varied Flow, Non-uniform flow in open channels, Gradually varied flow equations, Type of GVF profiles, Computation of GVF profiles.

Steady Rapidly Varied Flow, Hydraulic jump in a horizontal rectangular channel, Specific force, Computation of energy loss.

Unsteady Flow, Celerity of a gravity wave, Monoclonal rising wave, Positive and negative surges, St. Venant's equations, Method of characteristics, Hydraulic routing.

Learning Resources:

Text Books:

1. Open Channel Hydraulics, Chow,V.T., McGraw Hill Inc. N York, 1979
2. Open Channel Hydraulics, French, R.H., McGraw Hill Pub Co., N York, 1986

Reference Books:

1. Flow in Open Channels, Subramanya, K., Tata McGraw Hill Pub., 2008
2. Open Channel Hydraulics, Terry Sturm, Tata McGraw Hill Pub., 2011

Online Resources:

1. https://nptel.ac.in/courses/105/106/105106114/

Course Code: CE5762	URBAN WATER MANAGEMENT	Credits 3-0-0: 3

Pre-Requisites: NONE

Course Outcomes: At the end of the course, the student will be able to

CO1	Identify factors affecting urban hydrological cycle
CO2	Estimate urban water demand and urban stormwater quantity
CO3	Plan and design stormwater control and disposal systems
CO4	Develop integrated urban water management system

CO-PO/PSO mapping:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		2	3		
CO2	1		2	3		1
CO3	2		3		3	1
CO4	2		3		3	2

Syllabus:

General introduction to urbanisation and its effect on water cycle – urban hydrological cycle – trends in urbanisation – Effect of urbanisation on hydrology, Concepts of Smart City.

Time of concentration – importance of short duration of rainfall and runoff data – methods of estimation of time of concentration for design of urban drainage systems.

Master drainage plans – issues to be concentrated upon – typical content of an urban drainage master plan – interrelation between water resources investigation and urban planning processes – planning objectives – comprehensive planning – use of models in planning.

Basic approaches to urban drainage – runoff quantity and quality – wastewater and stormwater reuse – major and minor systems, Elements of drainage systems – open channel – underground drains – appurtenances – pumping – source control.

Stormwater Analysis Calculation of runoff and peak – Design of stormwater network systems, Performance evaluation of urban drainage systems, Best Management Practices – Detention and retention facilities – Swales- constructed wetlands.

Operation and maintenance of urban drainage system – interaction between stormwater management and solid waste management, Various model available for stormwater management, Legal aspects.

Learning Resources:

Text Books:

1. Manual on Storm Water Drainage Systems, Central Public Health and Environmental Engineering Organization, MOHUA, 2019

2. Manual on Drainage in Urban Areas, 2 Volumes, Geiger, W.F., Marsalek, J. Z., and Rawls, G.J., UNESCO, 1987
3. Urban Hydrology, Hall, M.J., Elsevier, 1984

Reference Books:

1. Storm Water Detention for Drainage, water quality and CSO Management, Stahre, P. and Urbonas, B., Prentice Hall, 1990
2. Storm Water Management, Wanielista, M.P. and Yousef, Y.A., John Wiley and Sons Inc., 1993

Online Resources:

1. https://serc.carleton.edu/integrate/teaching_materials/water_cities/overview.html

Course Code: CE5763	CLIMATE AND CLIMATE CHANGE MODELLING	Credits 3-0-0: 3

Pre-Requisites: NONE

Course Outcomes: At the end of the course, the student will be able to

CO1	Explain the basic concepts of climate and climate systems
CO2	Comprehend the drivers of climate change
CO3	Explain the climate models
CO4	Assess the impacts of climate change on Hydrology and Water Resources
CO5	Develop strategies for adaptation for climate change

CO-PO/PSO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		3	1	1	2
CO2	1		3	2		3
CO3	1		3	1		2
CO4	2		3	3		3
CO5	2		3	1	3	3

Syllabus:

Description of the climate system: Basic concept of climate, climate & weather, climatic classification, GHG emission, IPCC, Teleconnections, Climate and land-use feedback

Climate Change & Variability: Climate change drivers, past, present and future climate change, climate variability on various spatio-temporal scales, climate change scenarios over India

Climate Modelling: Simple climate models, General Circulation Models, Coupled ModelsStatistical and dynamic downscaling

Impact of climate change on hydrological processes, and hydrological extremes, Assessment of future water resources

Climate Change Adaptation: Climate change adaptation capacity and methodology analysis, Adaptation aspects over India

Sustainable Development over India: Climate-friendly initiatives, sustainable development and national planning

Learning Resources:

Text Books:

1. Climate change modeling, mitigation, and adaptation, Rao Y.S., Zhang, C.T., Ojha, C.S.P., Gurjar, B.R., Tyagi, R.D. & Kao C.M., ASCE, 2013
2. Climate System Modeling, Kevin E Trenberth, Cambridge University Press, 2010

Reference Books:

1. The Climate Modeling Premier, Kendal McGuffie, Ann Henderson-Sellers, Wiley-Blackwell, 2014, 4th Edition

2. Climate Change: What Everyone Needs to Know, Joseph J. Romm, Oxford University Press, 2016

Online Resources:

1. Climate Change synthesis report (2007), IPCC, https://www.ipcc.ch/reports/
2. Climate Change 2014: Impacts, Adaptation and Vulnerability, IPCC, https://www.ipcc.ch/reports/
3. Climate Change 2013: The Physical Science Basis, IPCC, https://www.ipcc.ch/reports/

Course Code: CE5764	ADVANCED HYDROLOGIC MODELLING	Credits 3-0-0: 3

Pre-Requisites: CE5701

Course Outcomes: At the end of the course, the student will be able to

CO1	Classify forecasting and prediction problems in hydrology
CO2	Develop a basic knowledge on modelling and simulation of a hydrologic system
CO3	Build linkage between hydrological processes
CO4	Make use of selected hydrological models

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		2	1	1	1
CO2	1		3	1	2	1
CO3	1		3	3	2	1
CO4	2		3	3	2	1

Syllabus:

Introduction to Hydrologic Modelling: Systems Approach, Linear Models - Deterministic and Probabilistic; Nonlinear Models - Deterministic and Probabilistic.

Introduction to Parameters and Variables; Introduction to Calibration of Models (Complexity); Introducing Model Calibration as an Optimization Problem; Introduction to Validation of Models-Different Validation Techniques; Performance Evaluation of Models.

Watershed Hydrological Models: Introduction to hydrological modelling concepts – Evolution of Rainfall-runoff models; Difference between conceptual and process-based models; Difference between lumped and distributed models; Conceptualizing the interaction between hydrological processes; Data requirement for hydrological models.

Development of Hydrological Models: Introduction to a conceptual watershed model viz. GR4J, HYMOD, HBV etc.; Introduction to process-based watershed hydrologic models viz. SWAT Model, VIC, etc.;

Sensitivity and Uncertainty Analysis: Simple methods - Linear; Monte Carlo Simulation; Sensitivity Analysis - Sobols' Method; Uncertainty Analysis - Introduction, First Order Uncertainty Analysis, GLUE

Application of Hydrological Models: Simulation-Optimization Framework - Watershed Management Decisions; Application of Simulation-Optimization Framework - Deficit Irrigation Management; Formulation of Case Examples of Simulation-Optimization Problems

Learning Resources:

Text Books:

1. Rainfall-Runoff Modelling: The Primer, Beven, K.J., John Wiley and Sons Ltd., 2006
2. Applied Hydrology, Chow, V.T., Maidment, D.R., and Mays, L.W., Tata McGraw Hill Edition, 2010 2nd Edition

3. Water Resources Systems Planning and Management – An introduction to methods, models and applications, Loucks, D.P. and Eelco van Beek, UNESCO and Springer, 2017

Reference Books:

1. Soil Water Assessment Tool theoretical documentation. Version 2009, Neitsch, S. L., Arnold, J. G., Kiniry, J. R., Williams, J. R., and King, K. W., Texas Water Resource Institute, college station, Texas. TWRI Report, TR-191, 2009
2. Introduction to Hydrology, Viessman, W., and Lewis, G.L., Prentice Hall of India, 2008 5th Edition

Online Resources:

1. https://nptel.ac.in/courses/105/101/105101002/

Course Code: CE5765	APPLICATION OF SOFT COMPUTING TECHNIQUES	Credits 3-0-0: 3

Pre-Requisites: NONE

Course Outcomes: At the end of the course, the student will be able to

CO1	Comprehend the characteristics of Soft Computing Techniques
CO2	Develop neural network models with applications in hydrology and water resources
CO3	Apply fuzzy logic and fuzzy reasoning for decision making
CO4	Apply evolutionary optimization techniques in water resources

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		2			
CO2	2		3	2	2	1
CO3	2		3	1	3	
CO4	2		3		3	

Syllabus:

Introduction, Soft computing, and computational intelligence, Need for soft computing techniques, Components of soft computing, Characteristics of soft computing

Introduction to Artificial Neural Networks, Definition and Fundamental concepts, Biological Neural Network – Model of a Neuron, Activation functions, Typical architectures, Knowledge representation, Artificial intelligence and neural networks, Leaning process.

Supervised learning, Feed forward neural networks, Back propagation learning algorithm, Application of feed forward ANN for function approximation and prediction, Support Vector Machine(SVM), Applications of feed forward networks and SVM in Hydrology and Water Resources Engineering

Deep Learning, Recurrent neural networks, Long Short-term Memory, Gated recurrent unit, Convolution neural network, Deep learning applications for time series, spatial data sets, Hydrometeorological and environmental applications of deep learning.

Information and uncertainty, Chance versus ambiguity, Classical sets and fuzzy sets, Logic and reasoning, Fuzzy set operations and fuzzy relations, Membership Functions, Fuzzy Systems, Fuzzy inference systems, Fuzzy Classification and Pattern Recognition, Neuro-Fuzzy Systems

Introduction to evolutionary optimization, concepts of genetic algorithm, genetic representation and selection mechanisms, genetic operators, overview of other evolutionary optimization techniques – Differential Evolution, Ant Colony Optimization, Particle Swarm Optimization and Simulated Annealing.

Learning Resources:

Text Books:

1. Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, Jang, J.R, Sun Chuen-tsai, and Mizutani Eiji, PHI Learning, 2009

2. Principles of Soft Computing, S.N. Sivanandam and S.N. Deepa, Wiley India, 2018
3. Nature-Inspired Optimization Algorithms, Xin-She Yang, Academic Press, 2020
4. Deep Learning for Hydrometeorology and Environmental Science, Taesam Lee, Vijay P. Singh and Kyung Hwa Cho, Water Science and Technology Library, Springer, 2020

Reference Books:

1. Neural Networks, Fuzzy Logic and Genetic Algorithms – Synthesis and Applications, Rajasekaran, S., and Vijayalakshmi Pai, G.A., Prentice-Hall India, New Delhi, 2017
2. Evolutionary Optimization Techniques, Dan Simon, Wiley, 2013

Online Resources:

1. https://www.sciencedirect.com/topics/engineering/artificial-neural-network
2. https://www.nature.com/articles/nbt1386
3. https://searchenterpriseai.techtarget.com/definition/fuzzy-logic

Course Code: CE5766	FLUVIAL HYDRAULICS	Credits 3-0-0: 3

Pre-Requisites: CE5702

Course Outcomes: At the end of the course, the student will be able to

CO1	Identify the characteristics and properties of sediments
CO2	Comprehend the concept of incipient motion
CO3	Analyze and compute the bed load and suspended load
CO4	Design guide bunds and other river training banks

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		2	3		
CO2	1		2	3		
CO3	1		3	3	1	
CO4	1		3	1	3	1

Syllabus:

The sediment problems, significant sediment properties, properties of sediment mixture, properties of fluid and suspended sediment mixture, terminal fall velocity of sediment in fluid, beginning of sediment movement – Shields analysis, incipient motion of uniform and non-uniform sediments, critical tractive stress of non-uniform materials.

Bed Forms and Resistance: Bed load and suspended load transport for uniform and non-uniform bed material, various approaches for bed load transport, suspended load profile and suspended load equations, total load equations, sediment sampling, discharge concept for bed-load transport, sediment pickup function, sediment sorting and streambed armouring, total-load transport.

Stable channel design and sediment control, regime of flow, effective bed roughness, non-scouring erodible –boundary channels.

Bed level variations, degradation, aggradation, local scour, scour within channel contractions, scour downstream of structures, scour below horizontal pipelines, scour at bridge piers and abutments, scour counter measures, reservoir sedimentation and its monitoring.

Physical and mathematical models, dimensional analysis, concept of dynamic similitude for model studies, immobile bed model studies, mobile bed model studies, design of guide bunds and other river training banks.

Learning Resources:

Text Books:

1. Fluvial Hydraulics, Dey, S., Springer, 2014.
2. Mechanics of Sediment Transportation and Alluvial Stream Problems,Garde, R. J. and Ranga Raju, K. G.,New Age Publishers, 2007.
3. Principals of River Engineering,Jansen, P.P.H.,VSSD Publications, 1996.
4. River Morphology, Garde, R.J., New International Publishers, 2006

5. Erosion and Sedimentation, Julien, P.Y., Cambridge University Press, 1998.

Reference Book:

1. Scouring: hydraulic structures design manual series, vol. 2,Breusers, H. N. C., & Raudkivi, A. J., CRC Press, 2020.
2. Principles of River Hydraulics, Aronne Armanini, Springer International Publishing, 2018.
3. River Hydraulics, U. S. Army Corps of Engineers, University Press of the Pacific, 2004.

Online Resources:

1. https://www.routledge.com/IAHR-Design-Manual/book-series/TFIAHRHSDM

Course Code: CE5767	HYDROPOWER SYSTEMS	Credits 3-0-0: 3

Pre-Requisites: NONE

Course Outcomes: At the end of the course, the student will be able to

CO1	Estimate hydropower potential
CO2	Identify types of hydropower plants
CO3	Design penstocks and surge shaft
CO4	Plan the layout of a hydropower plant
CO5	Analyse water hammer and surges

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		2	2	2	
CO2	1		2	2	3	
CO3	2		3	1	3	
CO4	1		3	3		2

Syllabus:

Introduction to Hydropower Systems: sources of energy, role of hydropower in a power system.

Estimation of Hydropower Potential: Flow duration curves of gauge and ungauged streams, load curve, load factor, capacity factor, utilization factor, diversity factor, load duration curve, firm power, secondary power, prediction of load.

Planning and layout of Hydropower Plants: types of Hydropower Plants: Runoff river plants, general arrangement of runoff river plants, valley dam plants, diversion canal plants, high head diversion plants, storage and pondage, pumped storage power plants, micro power plants.

Penstocks: Classification of penstocks, economical design of penstocks, losses, anchor blocks, valves, bends and manifolds.

Trash racks: Types, losses, design, stability.

Intakes: Types, losses, air entrainment, anti-vortex device, air vent, power channels, forebay, tunnel.

Turbines: Introduction, types of turbines, hydraulics of turbines, draft tubes, cavitation in turbines, turbine model testing, characteristics of turbines, selection of turbine.

Water Hammer and Surges: Introduction, water hammer, transients caused by turbine, load acceptance and rejection, resonance in penstocks, channel surges.

Surge Tanks: Functions, types of surge tanks, differential surge tanks, design of surge tanks- Calame-Gaden equations, Johnson's method, stability of surge tanks.

Learning Resources:

Text Books:

1. Water Power Engineering, Dandekar, M.M., and Sharma, K.H., Vikas Publishing House Pvt. Ltd. 2000.
2. Water Power Engineering, Barrows, H.K., Tata McGraw Hill Publishing Company Ltd. 1943.
3. Hydro Power Structures, Varshney, R.S., Nem Chand & Bros. 2001.

Reference Books:

1. Hydro Electric Engineering, Nigam, P.S., Nem Chand & Bros. 2001.
2. Applied Hydraulic Transients, Choudhary, M.H., Van Nostrand Reinhold Company 1987.
3. Fluid Transients, Streeter, V.L., and Wylie, B., McGraw-Hill Book Company. 1967.
4. Hydropower Engineering, Warnick, C.C., Prentice-Hall. 1984.
5. Norwegian Institute of Technology: Hydropower Development: Vols. 3, 4, 5 & 6, Division of Hydraulic Engineering. 1992-93.

Online Resources:

1. https://www.energy.gov/eere/water/hydropower-resource-assessment-and-characterization
2. https://www.hydropower.org/iha/discover-types-of-hydropower

Course Code: CE5768	APPLICATIONS OF REMOTE SENSING & GIS IN WATER RESOURCES & ENVIRONMENTAL ENGINEERING	Credits 3-0-0: 3

Pre-Requisites: NONE

Course Outcomes: At the end of the course, the student will be able to

CO1	Apply basic principles of remote sensing for resource mapping and evaluation
CO2	Develop geospatial data base of water resources and environmental engineering systems
CO3	Apply GIS models for hydrological simulation
CO4	Apply GIS models for planning environmental engineering systems

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		2	3	2	
CO2	1		2	3	2	
CO3	2		3	2	3	
CO4	1		3	2	3	2

Syllabus:

Physics of Remote Sensing: Sources of Energy, Active and Passive Radiation, Electromagnetic Spectrum - Reflectance, Transmission, Absorption, Thermal Emissions, Interaction with Atmosphere, Atmospheric windows, Spectral reflectance of Earth's surface features, Multi concept of Remote Sensing, Fundamentals of Microwave Remote Sensing.

Data Analysis: Data Products and Their Characteristics, Data Pre-processing – Atmospheric, Radiometric, Geometric Corrections – Basic Pattern Recognition Concepts, Basic Principles of Visual Interpretation

Fundamentals of GIS – Information Systems, Modelling Real World Features Data, Data Formats – Spatial and Non-spatial, Components, Data Collection and Input, Data Conversion, Database Management – Database Structures, Files; Standard Data Formats, Compression Techniques, Hardware – Computing, printing and scanning systems

Introduction to Standard Packages like Arcview, ArcGIS, Autocad Map, Map Info etc.

Spatial Analysis and Modelling – Proximity Analysis, Overlay Analysis, Buffer Analysis, Network Analysis, Spatial Auto Correlation, Gravity Modelling, DTM/DEM, Integration with Remote Sensing data

Surface-Water Hydrologic Data, Spatial techniques for Surface-Water Hydrology Modeling, Surface-Water Hydrology Models, SWAT model and its applications;

Groundwater Data, Ground water Models and spatial techniques for Groundwater Modeling and Visualization, The ArcHydro Data Model.

Geospatial techniques for planning and design of Water-Supply and Irrigation Systems, Spatial Database Development for Wastewater and Storm water Systems, Geospatial technologies for Water Resources Monitoring and Forecasting; Spatial Decision-Support

Systems in River Basin Management; Spatial systems for floodplain mapping and management, GIS for Water-Quality Management Decision Support

Taxonomy of Environmental Models in the Spatial Sciences. Geographic Data for Environmental Modeling and Assessment. Applications of Remote Sensing and Geographic Information Systems in Wildlife Mapping and Modeling, Land Use Planning and Environmental Impact Assessment Using Geographic Information Systems

Learning Resources:

Text Books:

1. Textbook on Remote Sensing in Natural Resources Monitoring and Management, Agarwal, C. S., and Garg, P. K., Wheeler Publishing, Allahabad, 2000
2. Remote Sensing and Image Interpretation, Lillesand, T. M., and Keifer, R. W., John Wiley & Sons, N York, 1994

Reference Books:

1. Introduction to the Use of Geographical Information Systems for Practical Hydrology, Meijerink M. J., de Brouwer, H.A.M., Mannaerts, C. M., and Velenzuela, C. R., ITC publication no. 23, UNESCO, Paris, 1994
2. Remote Sensing – The Quantitative Approach, Swain, P. H., and Davis, S. M., McGraw-Hill Pub. Co. N York, 1987

Online Resources:

1. https://nptel.ac.in/courses/105/103/105103193/
2. http://civil.iisc.ernet.in/~nagesh/rs_gis.htm

Course Code: CE6749	DISSERTATION PART-A	Credits 0-0-0: 12

Course Outcomes: At the end of the course, the student will be able to

CO1	Identify and define a topic relevant to planning, analysis and operation of a water resources system of a region based on the socio-economical requirements
CO2	Make a critical review of the available literature on the topic
CO3	Conduct independent research to formulate and solve the chosen problem
CO4	Prepare technical report on the study carried out

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	1	1	1
CO2	3	3	3			
CO3	3	3	3	1	1	1
CO4	3	3	3			

Course Code: CE6799	DISSERTATION PART-B	Credits 0-0-0: 20

Course Outcomes:

At the end of the course, the student will be able to

CO1	Identify and define a topic relevant to planning, analysis and operation of a water resources system of a region based on the socio-economical requirements
CO2	Make a critical review of the available literature on the topic
CO3	Conduct independent research to formulate and solve the chosen problem
CO4	Prepare technical report on the study carried out

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	1	1	1
CO2	3	3	3			
CO3	3	3	3	1	1	1
CO4	3	3	3			

NOTE: Refer to the following link for the guidelines to prepare dissertation report: https://www.nitw.ac.in/main/PGForms/NITW/