Teaching and Examination Schemes with Syllabus

of

Master of Technology (Civil)

in

Water Resources Engineering

As per NEP

(Approved by 62nd meeting of Senate dated August 6, 2024)

Department of Civil Engineering
Sardar Vallabhbhai National Institute of Technology, Surat

Teaching Scheme

M.Tech in WATER RESOURCES ENGINEERING

Sr. No.	Subject	Code	Scheme L-T-P	Exam Scheme Th. Marks	Exam Scheme T Marks	Exam Scheme P Marks	Credits (Min.)	Notional hours of Learning (Approx.)
	First Semester							
1	Core subject – 1 **Advanced Fluid Mechanics**	CEWR101	3-1-0	100	25	-	4	70
2	Core Subject – 2 **Free Surface Flow**	CEWR102	3-1-0	100	25	-	4	70
3	Core subject – 3 **Advanced Hydrologic Analysis and Design**	CEWR103	3-1-0	100	25	-	4	70
4	Elective -1	CEWR###	3-0-0	100	-	-	3	55
5	Elective - 2	CEWR###	3-0-0	100	-	-	3	55
6	**Computational Techniques in Water Resources Engineering Laboratory**	CEWR104	0-0-2	-	-	100	1	40
7	**Hydraulic Engineering Laboratory-I**	CEWR105	0-0-2	-	-	100	1	40
						Total	**20**	**400**
8	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	METMV01 METMP01	3-1-0				-	200 (20 x 10)
	Second Semester							
1	Core subject – 4 **Geospatial Techniques for Water Resources Engineering**	CEWR201	3-0-2	100	-	50	4	85
2	Core Subject – 5 **Water Resources Systems Engineering**	CEWR202	3-1-0	100	25	-	4	70
3	Elective -3	CEWR###	3-0-0	100	-	-	3	55
4	Elective -4	CEWR###	3-0-0	100	-	-	3	55
5	Institute Elective*****	$$##nXX	3-0-0	100	-	-	3	55
6	Computational Hydraulics Laboratory	CEWR203	0-0-3	-	-	100	1.5	55
7	Hydraulic Engineering Laboratory-II	CEWR204	0-0-3	-	-	100	1.5	55
						Total	**20**	**430**
8	Vocational Training / Professional Experience	METMV02 METMP02	0-0-10				5	200 (20 x 10)

L: Lecture; T: Tutorial; P: Practical; Th: Theory

*****to be offered to the PG students of other department and other PG Programs with the department.

Subject Code: Core, Electives, Dissertation Preliminary and Dissertation: **$$##nXX;** Vocational Training: **$$##VXX;** Professional Experience: **$$##PXX;**

$$: Department Name; **##**: M.Tech Course Identity; **n**: Year; **XX**: Core (01 to 10), Elective (11 to 70), Institute Elective (71 to 90), Vocational Training (91 to 92), Vocational Training (93 to 94), Dissertation Preliminary (95), Dissertation (96)

XX last digit odd number (for odd semester); XX last digit even number (for even semester)

Calculation of Notional Hours for the subject containing Theory, Tutorial and Practical

Example: 3-1-2: 3*15+1*15+2*15+10 (Exam)= 100

Sr. No.	Subject	Code	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
			Th.	T	P		
			Marks	Marks	Marks		
	Third Semester						
1	MOOC course – I*	φ	-	-	-	3/4	70/80
2	MOOC course – II*	φ	-	-	-	3/4	70/80
3	Dissertation Preliminaries	CEWR301	-	-	350$	14	560
				Total		**20-22**	**700-720**
	Fourth Semester						
1	Dissertation	CEWR401	-	-	600$	20	800

$ **Internal**: 40% and **External**: 60%

*Swayam/NPTEL

φ As per 66th IAAC, Dated 20th March, 2024, Resolution No. 66.34 and 61st Senate resolution No. 4, 25th April, 2024

ELECTIVES (SEMESTER 1) (Core Elective I and II)			
Code	**Course Name**	**Scheme**	**Credit**
CEWR110	Computational Techniques in Water Resources Engineering	3-0-0	3
CEWR111	Flood Control and River Training Works	3-0-0	3
CEWR112	Hydropower Engineering	3-0-0	3
CEWR113	Integrated Watershed Management	3-0-0	3
CEWR114	Stochastic Hydrology	3-0-0	3
CEWR115	Water Supply Distribution Systems	3-0-0	3

ELECTIVES (SEMESTER 2) (Core Elective III and IV)			
Code	**Course Name**	**Scheme**	**Credit**
CEWR210	Advanced Hydraulic Structures	3-0-0	3
CEWR211	Hydraulics of Alluvial Rivers	3-0-0	3
CEWR212	Irrigation and Drainage Systems Engineering	3-0-0	3
CEWR213	Ground Water Engineering	3-0-0	3
CEWR214	Computational Hydraulics	3-0-0	3
CEWR215	Climate Change Studies	3-0-0	3
CEWR216	Water Infrastructure in Smart Cities	3-0-0	3

INSTITUTE ELECTIVE-1 (SEMESTER 2)			
Code	**Course Name**	**Scheme**	**Credit**
CEWR215	Climate Change Studies	3-0-0	3
CEWR216	Water Infrastructure in Smart Cities	3-0-0	3

SEMESTER – I
CEWR101
Core 1: ADVANCED FLUID MECHANICS

L	T	P	Credit
3	1	0	4

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Identify the fluid flows and accordingly application of basic laws of fluid mechanics to solve real time problems.
CO2	Analyze viscous flow and flow instability
CO3	Appraise the boundary layer theory and its application
CO4	Analyze turbulent flow
CO5	Apply unsteady flow in pipe

2. Syllabus

EQUATIONS GOVERNING FLUID FLOW **(07 Hours)**

Reynolds transport theorem, law of conservation of mass-continuity equation, law of conservation of momentum- equation of motion, law of conservation of energy- energy equation.

POTENTIAL FLUID FLOW **(08 Hours)**

Standard flow pattern- uniform flow, source, irrotational vortex circulation, doublet, source and sink, vortex pair; source and vortex-spiral flow; source and uniform flow-flow past a half body; doublet and uniform flow-flow past a half body; source, sink and uniform flow- flow past a Rankine body; doublet and uniform flow-flow past cylinder, Doublet, vortex and uniform flow-flow past a cylinder with circulation; Magnus effect.

VISCOUS FLOW AND FLOW INSTABILITY **(08 Hours)**

Equation of motion–Navier-Stokes equation, Exact and approximate solutions of N-S equation, creeping motion, theory of instability of laminar flow- methods of small disturbance, stability analysis, Orr- Sommerfeld equation, solution of OSE equation- neutral stability curve, stages of transition from laminar to turbulent flow, factors affecting transition from laminar to turbulent flow.

BOUNDARY LAYER THEORY **(09 Hours)**

Factors affecting growth of boundary layer, momentum thickness, displacement thickness, energy thickness, order of magnitude analysis, Prandtl's boundary layer equation, exact solution of laminar boundary layer equation for flow on a flat plate, von Karman momentum integral equation and its application in computation of boundary shear stress, drag, local and average coefficients of friction for laminar and turbulent boundary layers, factors affecting separation of boundary layer and its control.

TURBULENT FLOW **(08 Hours)**

Characteristics of turbulent flow, types of turbulent flow, averaging procedure, Reynolds equation for turbulent flow from N-S equation, Prandtl's mixing length theory for two-dimensionalparallel flows, Karman-Prandtl's universal velocity distribution, smooth and and rough turbulent flow and their velocity distributions, Moody's diagram - friction factor and its variation with Reynolds number and relative roughness.

UNSTEADY FLOW IN PIPE **(05 Hours)**

Water hammer, Rigid and elastic water column theories, methods of analysis.

[Total Hours: 45 Hours, Tutorial: 15 hours]

3. References

1. Fox, W.R., and McDonald, A.T., "Introduction to Fluid Mechanics", Wiley andSons Inc., New York, 2003 (Sixth Edition).
2. Jain, A. K., "Fluid Mechanics", Khanna Publishers, New Delhi, 2012 (Twelfth Edition)
3. Streeter, V.L., Bedford, K. and Wylie, E. B., "Fluid Mechanics", McGraw Hill Book Company Ltd., New York, 2017 (Ninth Edition).
4. White, F. M., "Fluid Mechanics", The McGraw Hill Companies, 2016 (Eighth Edition)
5. Schlisting, H., Gersten, K., "Boundary Layer Theory", Springer Publication, 2000 (EighthEdition)

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	1	3	2	1
CO2	3	2	1	3	2	1
CO3	3	2	1	3	2	1
CO4	3	2	1	3	2	1
CO5	3	2	1	3	2	1

CEWR102

Core 2:FREE SURFACE FLOW

L	T	P	Credit
3	1	0	4

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Compute uniform flow
CO2	Apply non-uniform flow concepts to solve the field problems
CO3	Evaluate spatially varied flow
CO4	Analyse unsteadiness and hydrodynamics of fluid flow.
CO5	Apply numerical methods for unsteady flow

2. Syllabus

UNIFORM FLOW **(06 Hours)**

Specific energy curve and its limitations, critical depth and section factor for critical and uniform flow computations, open channel flow transitions, standing wave, venturi flumes, control sections and hydraulic exponent for critical and uniform flow computations.

NON-UNIFORM FLOW **(08 Hours)**

Assumptions in GVF analysis, dynamic equation of GVF, classification of channel slopes, GVF profiles, its identification and computation, applications, Specific force curve and its application in the analysis of hydraulic jump, hydraulic jump characteristics.

SPATIALLY VARIED FLOW **(08 Hours)**

Basic principles and assumptions, differential equations, analysis of flow profiles and flow through side weirs and bottom racks.

UNSTEADY FLOW **(09 Hours)**

Waves, classification of waves, waves celerity, occurrences of unsteady flow, height and celerity of gravity waves, governing equations for one dimensional flow, St. Venant equations and numerical methods.

UNSTEADY FLOW NUMERICAL METHODS **(08 Hours)**

Method of characteristics, Finite difference methods, explicit and implicit finite difference schemes, consistency, stability.

TWO-DIMENSIONAL FLOW **(06 Hours)**

Governing equations, MacCormack scheme, Gabutti scheme, artificial viscosity, finite volume scheme, applications.

[Total Hours: 45 Hours, Tutorial: 15 hours]

3. References

1. Asawa, G. L., “Fluid Flow in Pipes and Channels”, CBS Publishers & Distributors, New Delhi, 2017.
2. Chaudhary, H. M., “Open Channel flow”, Springer, 2007 (Second Edition).
3. Chow, V. T., “Open Channel Hydraulics”,The Blackburn Press, 2009 Edition.
4. Subramanya, K., “Flow in open channels”, Fifth edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2019.
5. Srivastava, R., “Flow through open channels”, Oxford Higher Education, Oxford University Press, 2007.

5. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	3	3	2	2
CO2	3	1	3	3	2	2
CO3	3	1	2	3	2	2
CO4	2	1	2	2	1	3
CO5	2	1	2	2	1	3

CEWR103

Core 3: ADVANCED HYDROLOGIC ANALYSIS AND DESIGN

L	T	P	Credit
3	1	0	4

1. Course Outcomes (Cos)

At the end of the Course the students will be able to:

CO1	Synthesize the solution including precipitation, evapo-transpiration and infiltration processes
CO2	Estimate flood hydrographs for gauged and ungauged catchments.
CO3	Apply flood routing models to rivers and reservoirs.
CO4	Compute IDF curves and floods of different return periods.
CO5	Design of Storm Drainage network

2. Syllabus

PRECIPITATION AND EVAPOTRANSPIRATION (12 Hours)

Global hydrological cycle, Atmospheric water, water vapour, Greenhouse effect, Computation and measurement of precipitation, missing data analysis and check on consistency of data, trend analysis, evaporation, evapo-transpiration, spatio-temporal distribution of rainfall.

FLOW THROUGH UNSATURATED ZONE (08 Hours)

Unsaturated flow models for potential infiltration rate - Horton's equation, Philips equation and Green-Ampt model, Models for actual infiltration rate, Computation of excess rainfall hyetograph from observed flood hydrograph using ϕ-index, and SCS (NRCS) curve number method.

FLOOD ESTIMATION METHODS- DETERMINISTIC APPROACHES (10 Hours)

Unit hydrograph theory, derivation of instantaneous unit hydrograph and synthetic unit hydrograph. Rational method, Project hydrology Design flood PMF storm transportation, PMP and PMF for project by using conceptual models, Introduction to glacier lake outburst flood (GLOF).

FLOOD ROUTING (07 Hours)

Lumped flow routing, distributed flow routing models including kinematic, diffusion and dynamic wave routing models. Numerical solutions of distributed flow routing models.

HYDROLOGIC STATISTICS (08 Hours)

Hydrologic statistics, Flood forecasting and flood frequency analysis. Hydrologic design of storm water drainage system, preparation

[Total Hours: 45 Hours, Tutorial: 15 hours]

3. References

1. Chow, V. T., Maidment, D. R., and Mays, L. W., "Applied Hydrology", McGraw Hill International editions, New Delhi, 2017.
2. Subramanya, K., "Engineering Hydrology", Fourth Edition, Tata McGraw-Hill Publishing company Ltd., New Delhi, 2017.
3. Singh, V. P., "Elementary Hydrology", Prentice Hall, New Delhi,1991.
4. Ojha, C. S. P., Bhunya, P., and Berndtsson, P., "Engineering Hydrology", Oxford University Press, Noida, 2008.
5. Raghunath, H. M., "Hydrology Principles, Analysis and Design", New Age International Pvt. Ltd., New Delhi, 2015.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	3
CO2	2	2	3	2	3	2
CO3	2	2	3	2	3	2
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3

CEWR110

Core Elective 1 and 2: Computational Techniques in Water Resources Engineering

L	T	P	Credit
3	0	0	3

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Ascertain use of spreadsheet and statistical techniques in water resources engineering.
CO2	Apply numerical methods to water resources engineering.
CO3	Practice advanced numerical techniques in water resources engineering.
CO4	Solve water resources problems using software and hydro informatics.
CO5	Analyse complex water resources engineering problems using computational techniques.

2. Syllabus

INTRODUCTION **(03 Hours)**
Computational Techniques, Database design, Spreadsheet.

STATISTICAL TECHNIQUES **(12 Hours)**
Presentation of data, Measures of location and dispersion, Probability concepts and distribution, Tests of significance, Correlation and Regression, Selection of suitable statistical technique.

NUMERICAL METHODS **(10 Hours)**
Finite difference schemes, Method of characteristics, Finite element method, Finite volume method.

HYDRO-INFORMATICS **(12 Hours)**
Introduction, Genetic Algorithm, Artificial Neural Network, Fuzzy Logic, Other data driven methods, Virtual institute, Web based hydro informatics system

APPLICATIONS **(08 Hours)**
Application with case studies, Selection of suitable computational technique, Different types of hydraulic engineering software: Salient features, Capabilities and limitations.

[Total Hours: 45 Hours]

3. References:

1. Abbott, M. B., “Hydroinformatics: Information Technology and the Aquatic Environment”, Avebury Technical, Aldershot, 1991.
2. Chaudhry, M. H., “Open Channel Flow”, Springer Science, New York, 2007(Second Edition).
3. Grewal, B. S., “Higher Engineering Mathematics”, Khanna Publishers, New Delhi, 2015(Forty Fourth Edition).
4. Govindaraju, R. S., and Rao, A. R., (eds.) “Artificial Neural Networks in Hydrology”, Springer, 2010 (2000 Edition).
5. Rajsekaran, S., and VijayalakshmiPai, G.A., “Neural Networks, Fuzzy Logic and Genetic Algorithms-Synthesis and Applications”, PHI Learning Pvt. Ltd., New Delhi, 2013

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	2	2	2	3
CO2	3	1	3	2	2	3
CO3	3	1	3	2	3	3
CO4	3	1	3	3	3	3
CO5	3	2	3	3	3	3

CEWR111

Core Elective 1 and 2: FLOOD CONTROL AND RIVER TRAINING WORKS

L	T	P	Credit
3	0	0	3

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Assess morphologicalbehaviour in alluvial rivers
CO2	Predict local scour in alluvial river.
CO3	Design river training works.
CO4	Apply Geo-Synthetics and other material in river training works
CO5	Compare flood control methods using soft computing techniques.

2. Syllabus

MORPHOLOGY AND HYDRAULICS OF ALLUVIAL RIVER (11 Hours)

Alluvial streams and their hydraulic geometry, bed level variation of alluvial streams, variation in plan form of alluvial streams, Analytical models of river morphology, Numerical models for morphological studies, flood plain analysis, morphology of some Indian rivers.

FLOOD CONTROL AND ITS ASSESSMENT (13 Hours)

Types of Floods, Different methods of Flood control, Floods in major Indian river basins, Types and design of flood forecasting and protection systems, Comparison of levees with bypass channels and off stream storage, reservoir operation for flood control and management, flood damage estimation models.

RIVER TRAINING AND FLOOD PROTECTION WORK (21 Hours)

Guide lines for planning and design of river embankments (levees), planning, design, construction and maintenance of guide banks and groynes for alluvial rivers, Application of Geo-synthetics and other materials in river training works, other structural and non-structural flood management strategies, DPR preparation for flood management.

[Total Hours: 45 hours]

3. References

1. Chow, V. T., Maidment, D. R., and Mays, L. W., “Applied Hydrology”, McGraw Hill International editions, New Delhi, 2017.

.

2. Garde, R. J., and Ranga Raju, K.G. ,“Mechanics of sediment transportation and alluvial stream problems”, New age International (P) Limited, Publishers”, New Delhi, 2000.

3. Garde, R. J., “River Morphology”, New Age International Publishers, New Delhi, 2006

4. Mays, L. W., “Hydraulic Design Handbook”, Mc Graw Hill Companies, New Delhi, 1999.

5. BIS 10751(1994), 12094 (2000), 12926 (1995), 8408 (1994)

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	1	2	3	1
CO2	3	2	1	2	3	1
CO3	3	1	2	2	3	1
CO4	3	1	2	2	3	1
CO5	3	1	2	3	2	1

CEWR112

Core Elective 1 and 2: Hydropower Engineering

L	T	P	Credit
3	0	0	3

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Identify Issues related to hydropower development in India.
CO2	Assess hydropower potential of river basins.
CO3	Evaluate efficacy of hydropower plants.
CO4	Design intake structures and water conveyance system.
CO5	Able to carry out power house planning.

2. Syllabus

Introduction **(02 hours)**
Energy sources for power generation, Power scenarios, Demand and supply of power, need of hydropower, General Hydrology, Environment and Hydro Power Development.

Planning for water power development **(04 hours)**
Introduction, Objectives of planning, planning for water power development, Estimation of available water, Power duration curve, Storage and pondage, Load studies, Technical terms related to hydropower, System integrated operational studies, Load prediction, Installed capacity, Size and number of units.

Topographical Survey and Geological/Geotechnical Investigation **(04 hours)**
Geological investigations studies for water power development, Geo technical investigations studies for water power development.

Power potential studies **(06 hours)**
Economics of Hydropower development, Economic value of hydropower, Cost of water power, Total annual cost of a hydro project (hydro power tariff), Operation and maintenance of hydro plants, hydro power markets.

Water Conveyance System **(08 hours)**
Intakes: Types, Location and Alignment of intakes, Losses in Intakes, Air- Entrainment at Intakes, Inlet aeration, Trash racks, Penstocks and Pressure Shafts, Surge shafts Hydrauli Valves and Gates

Classification and types of hydropower plants **(10 hours)**
Classifications, types, Storage power development, components of storage power development, economic aspects, social and rehabilitation aspects, Run-Off-River power Development, types of ROR, components of run-off-river power development, Run-of-power development on canal falls, Underground and pumped storage power plants, advantages, types and location of underground power station, its components, types of layout, limitations of underground power plants. Essential requirements of pumped storage power plant (PSPP), economics of PSPP, Cost of power generation.

Power House Planning **(07 hours)**
General layout of the power house and arrangement of hydropower units, Number and sizes f units, space allocation and dimensions, Super structure, Indoor, Semi-outdoor and Outdoor powerhouse, Lighting and Ventilation, Variation in design of power house, Safety requirements, Operation and maintenance of hydro plants.

Small Hydro Power Development **(04 hours)**
Introduction, Advantages of small hydropower, Classification of small hydropower, Components of small hydropower development, Choice of units, Economics of small hydropower schemes.

[Total Hours: 45 Hours]

3. References:

1. Dandekar, M. M., and Sharma, K. N., "Water Power Engineering", Vikas Publishing House, New Delhi,2013 (Second edition).
2. Deshmukh, M.M., "Water Power Engineering, Dhanpat Rai Publications", NewDelhi, 1998.
3. Nigam, N. C., "Handbook of Hydropower Engineering", Nem Chand and Sons, Roorkee, 1999.
4. Sharma, R. K. and Sharma, T. K., "Water Power Engineering", S.Chand& Company, New Delhi, 2003.
5. Varshney, R.S., "Hydropower Structures", NemChand and Bros., Roorkee (U.P.), 2014.

4.CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	1	2	1	1
CO2	2	1	2	2	2	2
CO3	2	2	1	2	1	3
CO4	2	2	2	2	2	2
CO5	3	3	2	1	2	1

CEWR113
Core Elective 1 and 2: INTEGRATED WATERSHED MANAGEMENT

L	T	P	Credit
3	0	0	3

---

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Assess behavior of Watershed
CO2	Describe Watershed and Hydro-geomorphology
CO3	Develop suitable models for various types of Watersheds
CO4	Plan the watershed conservation practices
CO5	Apply GIS technique for Watershed Management

2. Syllabus

INTRODUCTION TO WATERSHED (05 Hours)
Definition and its components, Need of watershed management, Identification of watershed problems, Sustainability with watershed management, Watershed assessment concept, Comprehensive watershed management concepts.

BEHAVIOUR OF PHYSIOGRAPHY IN WATERSHED ASSESSMENT AND MANAGEMENT (05 Hours)
Physiography and physiographic regions – Geology, Soil, Topography, Climate, Precipitation, Hydrologic cycle.

WATERSHED AND HYDRO-GEOMORPHOLOGY (10 Hours)
Watershed Classifications, Stream classifications, watershed hydrology, Surface water assessment, Rainfall-runoff analysis, Groundwater assessment, infiltration and its measurement, Erosion process: factors affecting erosion, types of erosion, soil erosion models.

WATERSHED HYDROLOGY AND MODELLING (10 Hours)
Drainage area, Time-of-concentration and watershed lag, Runoff routing, Modelling process, Case study of sensitivity analysis of watershed management and planning.

SOIL AND WATER CONSERVATION (10 Hours)
Physical measures for watershed management by soil and water conservation, Stormwater and flood management, Drought management, Integrated watershed management.

Geographical Information System (05 Hours)
Use of GIS and DEM for Watershed Assessment, GIS models its data requirement and limitations for Watershed assessment and analysis.

[Total Hours: 45 Hours]

3. References:

1. Murthy, J.V.S., "Watershed Management, New Age International (P) Limited Publishers", New Delhi, Reprint 2017(Second Edition).
2. FAO : Watershed Management and Field Manuals, UN, Rome, 1990.
3. Menon, S. V., "Watershed Management: Case Studies", ICFAI University Press, 2008.
4. Tideman, E. M., "Watershed Management – Guidelines for Indian conditions", Omega Scientific Publishers, New Delhi, 2007 (Eleventh Edition).
5. DeBarry, P. A., "Watersheds: Processes, Assessment and Management", Hoboken, NJ: Wiley, 2004(First Edition).

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	2	1	2	3
CO2	2	1	1	2	2	1
CO3	3	2	2	1	2	2
CO4	3	3	1	3	2	2
CO5	2	2	1	3	1	3

CEWR114
Core Elective 1 and 2:STOCHASTIC HYDROLOGY

L	T	P	Credit
3	0	0	3

1. Course Outcomes

At the end of the Course the students will be able to:

CO1	Apply knowledge of stochastic hydrology.
CO2	Appraise basic concepts of probability theory
CO3	Elaborate various types of time series analyses
CO4	Explain various types of stochastic models
CO5	Fit probability distribution to hydrologic data

2. Syllabus

INTRODUCTION **(02 Hours)**
Stochastic hydrology, Applications of stochastic hydrology.

FUNDAMENTALS OF STATISTICS **(10 Hours)**
Concept of probability, Discrete and continuous variables, Probability distributions including fitting to hydrological data.

TIME SERIES ANALYSIS **(08 Hours)**
Definitions and classification of time series. Stochastic processes. Components of time series. Trend analysis. Periodicity. Auto-correlation and spectral analysis. Frequency analysis.

STOCHASTIC MODELS **(13 Hours)**
Univariate models: classification of models, univariate annual models with normal and other distributions, univariate annual models obeying Hurst's law, univariate seasonal models. Multivariate models: multisite annual models, multisite AR models for seasonal flows, MA models, ARIMA models, non-stationary processes.

CASE STUDIES **(12 Hours)**
Examples related to fitting probability distributions. Trend analysis, Spectral analysis. Stochastic models in hydrologic forecasting.

[Total Hours: 45 Hours]

3. References:

1. Kottegoda, N. T., “Stochastic Water Resources Technology”, The Macmillan Press Ltd., 1980.
2. Singh, V. P., “Handbook of Applied Hydrology”, Second Edition, McGraw-Hill, New York, 2016.
3. Yevjevich, V., “Stochastic Processes in Hydrology”, Water Resources Publications, Fort Collins, Colorado, 1972.
4. Hann C.T., “Statistical Methods in Hydrology”, Wiley–Blackwell, 2002 (Second Edition).
5. Clarke R. T., “Mathematical Models in Hydrology”, FAO, 1973.

4.CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	1	2	1	1	1
CO2	1	1	2	1	1	1
CO3	1	1	2	1	1	1
CO4	1	1	2	1	1	1
CO5	3	2	3	3	2	3

CEWR115
Core Elective 1 and 2: Water Supply DistributionSystems

L	T	P	Credit
3	0	0	3

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Identify different intake structures and water treatment processes
CO2	Understand parameters involved in design of water distribution system
CO3	Design water distribution system
CO4	Optimize water distribution system.
CO5	Analyse surge in the pressurized water supply network.

2. Syllabus

INTRODUCTION **(04 Hours)**
Introduction to Intake structure, Water Quality, Hydraulics of water treatment processes.

TYPE OF DISTRIBUTION SYSTEMS **(08 Hours)**
Equivalent pipe, parameters in distribution system analysis, parameters interrelationship, Formulation of equation, Gravity and Rising Main, Location and Design Principles.

ANALYSIS OF WATER DISTRIBUTION SYSTEM **(10 Hours)**
Methods of analysis: (i) Hardy-Cross Method (ii) Newton-Raphson method and (iii) Linear Theory Method (iv) Gradient Method.

DESIGN AND OPTIMIZATION OF WATER DISTRIBUTION SYSTEM **(13 Hours)**
Design: Trial and error method of design, cost-head loss ratio method. Optimization using linear programming techniques, Surge analysis in water distribution systems, Pump duty stations and detailing valves, Pressure transients in pipe flow.

CASE STUDIES **(10 Hours)**
Case studies on new Water Distribution Systems, Rehabilitation systems, DPR preparation of a water supply system including operation and maintenance through SCADA.

[Total Hours: 45]

3. References:

1. Bhave, P. R., “Optimal Design of Water Distribution Networks”, Narosa Publishing House, New Delhi, 2003.

2. Streeter, V. L. and Wylie, E. D., “Fluid Transients in Systems”, Pearson., 2010.
3. Bhave, P. R., and Gupta, R., “Analysis of Water Distribution Networks”, Narosa Publishing House, New Delhi and Alpha-Science Publication, UK, 2006.
4. CPHEEO (1999), Manual on Water Supply and Treatment, Central Public Health and Environmental Engineering Organisation, Ministry Housing and Urban Affairs (Previously known as Ministry of Urban Development, New Delhi, Third Edition.
5. IS 10500:2012, Drinking Water-Specification, Second Revision, 2012.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	1	2	3	1
CO2	3	2	1	2	3	1
CO3	3	2	1	2	3	1
CO4	3	1	2	2	3	1
CO5	3	1	2	3	2	1

CEWR104
COMPUTATIONAL TECHNIQUES IN WATER RESOURCES ENGINEERING LABORATORY

L	T	P	Credit
0	0	4	2

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Ascertain use of spreadsheet and statistical techniques in water resources engineering.
CO2	Apply numerical methods to water resources engineering.
CO3	Practice advanced numerical techniques in water resources engineering.
CO4	Solve water resources problems using software and hydro informatics.
CO5	Analyze complex water resources engineering problems using computational techniques.

2. Syllabus

1. Application of spread sheet for hydrology / irrigation problem **(06 Hours)**

2. Application of spread sheet for water resource engineering **(04 Hours)**

3. Statistical analysis of given hydrology / irrigation problem **(06 Hours)**

4. Statistical analysis of given water resource engineering problem **(04 Hours)**

5. Application of numerical methods in water resource engineering **(06 Hours)**

6. Application of advanced numerical methods in water resource engineering **(06 Hours)**

7. Application of Hydro-informatics (IWRIS) **(06 Hours)**

8. Study of commonly used softwares related to water resource engineering **(06 Hours)**

9. Use of software for solving of water resource engineering problem **(06 Hours)**

10. Case study of computational techniques application **(04 Hours)**

11. Writing code for the specific water resources application **(06 Hours)**

[Total Hours: 60 hours]

3. References:

1. Abbott, M. B., “Hydroinformatics: Information Technology and the Aquatic Environment”, Avebury Technical, Aldershot, 1991.
2. Chaudhry, M. H., “Open Channel Flow”, Springer Science, New York, 2007(Second Edition).
3. Grewal, B. S., “Higher Engineering Mathematics”, Khanna Publishers, New Delhi, 2015(Forty Fourth Edition).
4. Govindaraju, R. S., and Rao, A. R., (eds.) “Artificial Neural Networks in Hydrology”, Springer, 2010 (2000 Edition).
5. Rajsekaran, S., and VijayalakshmiPai, G.A., “Neural Networks, Fuzzy Logic and Genetic Algorithms-Synthesis and Applications”, PHI Learning Pvt. Ltd., New Delhi, 2013

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	2	2	2	3
CO2	3	1	3	2	2	3
CO3	3	1	3	2	3	3
CO4	3	1	3	3	3	3
CO5	3	2	3	3	3	3

CEWR105

Hydraulic Engineering Laboratory – I

L	T	P	Credit
0	0	4	2

1. Course Outcomes

At the end of the Course the students will be able to:

CO1	Synthesize acquired theoretical knowledge with experimental observations for open channel flow.
CO2	Measure boundary layer characteristics and flow resistance on streamlined and bluff bodies.
CO3	Simulate experimentally rainfall and surface flows.
CO4	Simulate experimentally subsurface flow.
CO5	Analyse pressure transients.

2. Syllabus

Experimentsrelated tothefollowingaspectsof hydraulic engineering:

1. Development of uniform flow in open channel **(6 Hours)**
2. Measurement of velocity distribution in open channel using Pitot tube and plotting of isovels and computation of α and β. **(6 Hours)**
3. Establishment of subcritical, critical and supercritical flows in open channel, plotting of specific energy diagram. **(6 Hours)**
4. Characteristics of hydraulic jump in open channel. **(6 Hours)**
5. Measurement and computation of gradually varied flow profiles in open channel. **(6 Hours)**
6. Rainfall and runoff characteristics using rainfall simulator. **(6 Hours)**
7. Infiltrometer to study infiltration capacity of different types of soil. **(6 Hour**s)
8. Measurement of boundary layer thickness on flat plate. **(6 Hours)**
9. Measurement of drag and lift force coefficient for cylinder and spheres. **(6 Hours)**
10. Development of Synthetic Unit Hydrograph and flood hydrograph using CWC method**(6 Hours)**

[Total Hours: 60 Hours]

3. References:

1. Asawa, G. L., Laboratory Work in Hydraulic Engineering, New Age International Private Limited, 2016.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	2
CO2	3	2	3	3	3	1
CO3	3	2	3	3	3	2
CO4	3	2	3	3	3	2
CO5	3	2	3	3	3	2

SEMESTER – II

CEWR201
Core 4: GEOSPATIAL TECHNIQUES FOR WATER RESOURCES ENGINEERING

L	T	P	Credit
3	0	2	5

---

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Appraise the fundamentals of Remote Sensing
CO2	Employ Digital Image processing
CO3	Practice fundamentals and processes of GIS
CO4	Apply GPS technology and different methods of measurements
CO5	Solve complex civil engineering applications using Geospatial Techniques

2. Syllabus

INTRODUCTION **(01 Hours)**
Introduction to geospatial techniques - Benefits and applications of geospatial techniques

REMOTE SENSING **(09 Hours)**
Fundamentals of remote sensing - Energy interactions - Ideal remote sensing systems, - Fundamentals of interpretation - Basic equipments used for interpretation - Elements of air photo interpretation - Interpretation keys - Different types of sensors - Platforms and remote sensing images

DIGITAL IMAGE PROCESSING **(05 Hours)**
Characteristics of a digital image –Digital Image processing techniques– Image registration – Digital image interpretation techniques

GEOGRAPHICAL INFORMATION SYSTEMS **(14 Hours)**
Introduction - Geo referenced data - Data input and output - Data quality and management - GIS analysis functions - Implementation of GIS - Principles and methods of data collection – Digital Elevation Models

GLOBAL POSITIONING SYSTEM **(08 Hours)**
Earth Surface, datum – Co-ordinate systems - Segments of GPS System - GPS receivers and its components - Different methods of observation

ENGINEERING APPLICATIONS **(08 Hours)**
Application of Remote Sensing, GIS and GPS in different areas of Civil Engineering, Software in Geospatial Techniques, Use of Google Earth Engine, Applications using drones.

[Total Hours: 45 hours]

3.References:

1. Lillesand, T.M., Kiefer, R. W., and Chipman, J., "Remote Sensing and Image Interpretation", John Willey & Sons, New York, 2015.
2. Chandra, A.M. and Ghosh, S.K., "Remote Sensing and Geographical Information System", Alpha Science International Ltd, 2015(Second Edition).
3. Srivastava, G.S., "An Introduction to Geoinformatics", Mc Graw Hill Education (India) Pvt. Ltd., New Delhi, 2014
4. Agrawal, N.K., "Essentials of GPS",BS Publications, 2012.
5. Lo, C.P., and Yeung, A.K.W., "Concept and Techniques of Geographical Information Systems", PHI Learning Pvt. Ltd., New Delhi, 2008

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	2	2	2	3
CO2	3	1	3	2	2	3
CO3	3	1	3	2	3	3
CO4	3	1	3	2	3	3
CO5	3	2	3	3	3	3

LIST OF PRACTICALS

1.Study of different equipments used for image interpretation **(03 Hours)**

2. Study and interpretation of various remotely sensed data products / images **(03 Hours)**

3. Delineation of drainage patterns in the given study area **(03 Hours)**

4. Study of ERDAS Imagine software **(03 Hours)**

5. Study of ARC GIS software **(03 Hours)**

6. Digital image processing using software **(03 Hours)**

7. Geo referencing of the given area / image using software **(03 Hours)**

8. Study of GPS receiver and measurement of point, line and area **(03 Hours)**

9. Study and application of Pathfinder software **(03 Hours)**

10. Application / case study of geospatial techniques in WRE **(03 Hours)**

[Total Practical Hours: 30 hours]

CEWR202

L	T	P	Credit

Core 5: WATER RESOURCES SYSTEMS ENGINEERING

3	1	0	4

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Appraise system components and its significance
CO2	Evaluate different alternatives of water resources system
CO3	Implement project optimality conditions for the water resources project
CO4	Apply soft computing techniques to optimize water resources problems
CO5	Simulate water resources systems

2. Syllabus

INTRODUCTION (06 Hours)

Introduction to water resources system and system planning, Systems approach its advantages and limitations.

ECONOMICS OF WATER RESOURCES SYSTEMS (09 Hours)

Principles of Engineering Economics, Mathematics of economic analysis, Discounting factors and discounting techniques, Feasibility of water resources project, Selection of an alternative projects, Benefit cost analysis, Internal rate of return, Legal consideration in economic analysis, Conditions of project optimality.

CONVENTIONAL OPTIMIZATION TECHNIQUES (09 Hours)

Optimization: Functions of a single variable, Optimization: Functions of multiple variables, Constrained optimization, Kuhn-Tucker conditions, Linear Programming by graphical and simplex methods, Dynamic Programming and Stochastic Optimization techniques, Applications of LP and DPto water resources engineering problems, Optimum operation model for reservoir systems by incremental dynamic programming, Sequence of multipurpose projects. Information about the software's used to solve LP problems.

SOFT COMPUTING TECHNIQUES FOR WATER RESOURCES (12 Hours)

Optimization using fuzzy sets and Fuzzy Logic, Genetic Algorithm and Artificial Neural Network, Applications of Fuzzy Logic, Genetic Algorithm and ANN to water resources engineering

SIMULATION OF WATER RESOURCES SYSTEMS (06 Hours)

Operation of system based on If-Then rules, Case studies on reservoir simulation for competing objectives, Mathematical models for large scale multipurpose projects, River basin simulation, Performance evaluation: reliability, resiliency and vulnerability, Water resources system simulation models.

SYSTEM SENSITIVITY AND PERFORMANCE CRITERIA(03 Hours)

Variability, Sensitivity, Uncertainty analysis, Performance Criteria, Quantifying performance criteria, Multi criteria analyses, Statistical performance criteria.

[Total Hours: 45 Hours, Tutorial: 15 hours]

3. References:

1. Loucks, D. P., Beek, E. V., Stedinger,R. J.., Dijkman, J. P.M., and Villars, M. T., "Water Resources Systems Planning and Management: An Introduction to Methods, Models and Applications". Deltares, UNESCO-IHE, Springer, 2017.
2. James, L. D., and Lee, R. R., "Economic of Water Resources Planning", McGraw Hill, 1971.
3. Vedula, S. and Mujumdar, P. P., "Water Resources System", Tata McGraw Hill Company, 2005.
4. Raju, K.S. and Kumar, D. N., Multicriterion Analysis in Engineering and Management. PHI Learning Pvt. Ltd., 2014.
5. Goldberg, D.E.,"Genetic Algorithm in Search, Optimization and Machine learning Technique", Addison Wesley, Reading Mass, 1989.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	2	1	2
CO2	3	3	3	2	3	2
CO3	2	2	2	1	1	1
CO4	3	2	3	1	1	3
CO5	3	1	3	2	3	3

CEWR210

L	T	P	Credit

Core Elective 3 and 4: ADVANCED HYDRAULIC STRUCTURES	**3**	**0**	**0**	**3**

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Plan the selection of dam site, reservoir capacity and reservoir operation.
CO2	Identify the methods of hydraulic structure design.
CO3	Design of hydraulic structures.
CO4	Analysis of weir and barrages, canal regulating structures.
CO5	Design and selection of cross drainage works and energy dissipaters**.**

2. Syllabus

Planning of Water ResourcesProject **(05 Hours)**

Planning and investigations of reservoir and dam sites, Choice of dams, preparation and protection of foundation and abutments, dam safety and hazard mitigation.

Gravity Dam **(10 Hours)**

Forces acting on solid gravity dam, modes of failures, stability analysis, elementary and practical profile of gravity dam, internal stresses and stress concentrations in gravity dam, joints, seals, keys in gravity dams.

Embankment Dam **(10 Hours)**

Classification of embankment dam, Homogeneous and zoned embankment dams, factors influencing design of embankment dams, criteria for safe design of embankment dam, steps in design of embankment dam, seepage analysis and its control through dam and its foundation, design considerations for rock fill dam, instrumentation.

Spillways and Energy Dissipaters **(08 Hours)**

Capacity of spillways, components and profile of different types of spillways, Non-conventional type of spillways, selection and design of energy dissipaters, spillway aerator.

Diversion Headwork **(07 Hours)**

Components of diversion head works and their functions, design of weirs and barrages on permeable foundations

Design of Canal and Canal Structure **(05 Hours)**

Canal regulation structures and design of cross drainage works, canal falls, operation and maintenance of canals.

Review of codes of practice

[Total Hours: 45 Hours]

3. References:

1. USBR, Design of gravity dams, A Water Resources Technical Publication, Denver, Colorado, 1976.

2. Asawa, G. L., "Irrigation and water resources engineering", New Age International Publishers, New Delhi, 2014.

3. Creager, W. P., Justin, J. D., and Hinds, J., "Engineering for dams", Nemchand and Brothers, Roorkee, 1995.

4. Khatsuria, R. M., "Hydraulics of spillways and energy dissipaters", CRC Press, 2005 (First Edition).

5. Novak, P., Moffat,A.I.B., Nalluri,C., Narayanan,R., "Hydraulic Structures", CRC Press,2006 (Fourth Edition).

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	1	3	2	1
CO2	3	2	1	3	2	1
CO3	3	2	1	3	2	1
CO4	3	2	1	3	2	1
CO5	3	2	1	3	2	1

CEWR211

L	T	P	Credit

Core Elective 3 and 4: HYDRAULICS OF ALLUVIAL RIVERS	3	0	0	3

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Classify and estimate bed forms and flow resistance in alluvial rivers.
CO2	Estimate incipient motion conditions and sediment loads in alluvial rivers.
CO3	Design of lined and unlined channels using sediment transport concepts.
CO4	Analyse Hydraulic geometry of Alluvial Rivers
CO5	Predict bed level variations in alluvial rivers.

2. Syllabus

PROPERTIES AND INCIPIENT MOTION OF SEDIMENTS (6 Hours)
Nature of sediment problems, Origin and formation of sediments, individual and bulk properties of sediments, competent velocity, lift force and critical tractive stress concept on cohesion less and cohesive soils; regimes of flow.

FLOW RESISTANCE (5 Hours)

Resistance to flow in alluvial streams, resistance relations based on total resistance and division of resistance into grain and form resistance, preparation of stage discharge curves for alluvial streams, velocity distribution in alluvial channel, sediment Petrography (Sediment sampling)

BED LOAD TRANSPORTATION (08 Hours)
Bed load computation by empirical equations, dimensional considerations and semi theoretical equations for uniform and non-uniform sediments, saltation.

SUSPENDED LOAD TRANSPORTATION (07 Hours)
Mechanism of suspension, general equations of diffusion. Integration of sediment distribution equation, Differences between actual and theoretical exponents, prediction of reference concentration, Method of integrating curves of concentration and velocity. Simple relations for suspended load, Effect of temperature on suspended load, Wash load, Non-equilibrium transport of suspended load, Computation of total loads.

STABLE CHANNEL DESIGN (07 Hours)
Design of lined and unlined channels for carrying clear and sediment laden water.

ALLUVIAL RIVER MODELS **(12 Hours)**

Hydraulic geometry of alluvial streams, bed level variation of alluvial streams, aggradations and degradation models, reservoir sedimentation, local scours.

[Total Hours: 45 Hours, Tutorial: 15 hours]

3. References:

1. Shen, H. W.,"River Mechanics", Vol. I & II, Water Resources Publication, Colorado, 1971.
2. Garde, R. J., and Ranga Raju, K. G., "Mechanics of Sediment transportation and Alluvial Stream Problems", New Age International (P) Limited, New Delhi, 2000 (Third edition).
3. Garde, R. J., "River Morphology", New Age International Publisher, New Delhi, 2006.
4. Raudkivi, A. J., "Loose boundary hydraulics", Pergamon Press, Oxford (U. K.), 2nd edition, 1976
5. Yalin, M.S., "Mechanics of Sediment Transport", Pergamon Press, Oxford (U K), 1977.

4.CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	2	3	2	3	2
CO2	3	2	3	2	3	2
CO3	3	2	3	3	3	2
CO4	2	2	3	2	3	2
CO5	3	2	3	3	3	3

CEWR212
Core Elective 3 and 4: IRRIGATION AND DRAINAGE SYSTEMS ENGINEERING

L	T	P	Credit
3	0	0	3

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Select appropriate irrigation technique.
CO2	Describe Soil-Water-Crop Relationship
CO3	Develop suitable models for various irrigation methods.
CO4	Design drainage system for irrigated lands.
CO5	Apply soil conservation measures and reclamation of salt affected land.

2. Syllabus

INTRODUCTION (06 Hours)
Water resource in India and its present utilization, Development through five year plans, Roles of various commissions on irrigation and agriculture, National water policy, Types of irrigation, Irrigation methods and quality of irrigation water.

SOIL-WATER-CROP RELATIONSHIP (08 Hours)
Determination of soil moisture, Estimation of consumptive use and frequency of irrigation, Irrigation efficiencies for economical use of water, Design of various irrigation methods, Assessment of water charges, Conjunctive use of surface and ground water, Multi-crop irrigation scheduling.

MODELLING OF IRRIGATION SYSTEMS (08 Hours)
Governing equations and their solutions, Computation of inundation front, Cumulative infiltration estimation, Modelling for sprinklers and other methods of irrigation, Water Audit in irrigation systems.

SALT-AFFECTED LAND AND ITS RECLAMATION (08 Hours)
Salt accumulation in soil water, Classification of salts affecting the soils and their characteristics, Reclamation of saline and alkaline soils, Leaching and salinity control.

DRAINAGE OF IRRIGATED SOILS (08 Hours)
Need and purpose of drainage, Water logging of agricultural land and its reclamation, Steady state and transient designs of surface and sub-surface drainage systems, Drainage by wells.

SOIL EROSION AND CONSERVATION (07 Hours)
Water and wind erosion, Design of various types of soil conservation measures.

[Total Hours: 45 Hours]

3. References:

1. Asawa, G. L., “Irrigation and Water Resources Engineering”, New Age International Publishers, New Delhi, 2005.
2. Yaron, D., “Salinity in Irrigation and Water Resources”, Morcel Dekker Inc. New York, 1981.
3. Michael A. M., “Irrigation Theory and Practice”, S Chand publication, New Delhi, 2008 (Second Edition).
4. Richard, H., and Cuenca, “Irrigation System Design: An Engineering Approach”, Prentice Hall, Englewood Cliffs, New Jersey, 1989.
5. Majumdar, D. K., “Irrigation Water Management Principles and Practice”, PHI Publication New Delhi, 2013(Second Edition).
6. Central Water Commission,, “Guideline for Computing the Water Use Efficiency [WUE] of the Irrigation Projects, Performance Overview & Improvement Organisation, CWC.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	2
CO2	3	3	1	2	2	3
CO3	1	2	2	3	3	1
CO4	1	3	3	3	2	2
CO5	3	2	1	1	1	3

CEWR213

Core Elective 3 and 4: Ground Water Hydrology

L	T	P	Credit
3	0	0	3

---

1. Course Objectives

At the end of the Course the students will be able to:

CO1	Explain the occurrence of ground water
CO2	Understand the principles of well hydraulics and computation of aquifer yield
CO3	Identification and conceptualization of Artificial recharge of ground water and Groundwater modeling techniques
CO4	Analyse the problem of salt water intrusion
CO5	Assess transport of pollutants in ground water

2. Syllabus

INTRODUCTION (08 Hours)

Occurrence of ground water, geological formations as aquifers, types of aquifers, ground water movement, Darcy's law, permeability and its measurement, tracing of ground water movement, fundamental equations for steady and unsteady ground water flow, flow nets, Ground Water Scenario of India.

WELL HYDRAULICS (15 Hours)

Steady and unsteady flow in confined, semi-confined and unconfined aquifers, radial flow, superposition, multiple well system. Different methods of well construction; construction of well casings and screens, natural and artificial gravel packed wells. Safe yields, estimation, pumping and recuperation tests, Infiltration galleries.

ARTIFICIAL RECHARGE OF GROUND WATER (05 Hours)

Ground-water replenishment, Artificial recharge of ground water, different methods, merits, demerits, selection criteria for various methods, cone of depression.

GROUNDWATER MODELING TECHNIQUES (08 Hours)

Porous media models, analog models, electric analog models, digital computer models

SALT WATER INTRUSION (05 Hours)

Concept, interface and its location, control of intrusion.

POLLUTANT TRANSPORT IN GROUND WATER (04 Hours)

Pollutant transport, Plume Transport, source identification, tracer methods.

[Total Hours: 45 Hours]

3. References:

1. Todd, D. K., and Mays, L. W., “Groundwater Hydrology”,John Wiley publishers, 2011 (Third edition).
2. Bear J., “Hydraulics of Groundwater”, Dover Publications, 2013.
3. Raghunath, H. M., “Groundwater and Well Hydraulics”, New Age International Publishers, Delhi,2007 (Third Edition)
4. Rastogi, A. K., “Numerical Groundwater Hydrology”. UlhasPhatak for Penra International (I) Pvt. Ltd., Mumbai, 2007.
5. Driscoll, F. G., “Groundwater and Wells”, Johnson Filtration Systems Inc., Minnesota: 1986 (Second edition).

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	1	3	2	2
CO2	2	1	1	1	2	1
CO3	1	2	2	2	1	3
CO4	2	3	3	2	1	3
CO5	1	1	3	2	1	2

CEWR214

Core Elective 3 and 4: COMPUTATIONAL HYDRAULICS

L	T	P	Credit
3	0	0	3

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Recall concepts of fluid motion.
CO2	Derive and apply appropriate flood wave routing models.
CO3	Solve partial differential equations using numerical methods.
CO4	Apply numerical methods for flood waves, flow through saturated porous media and closed conduit flows.
CO5	Solve the real-world problems related to water flow

2. Syllabus

BASIC CONCEPTS OF FLUID MOTION (11 Hours)
Basic Concepts – Lagrangian and Eulerian methods of describing fluid motion, acceleration and deformation of fluid elements, Laws governing fluid motion, continuity, Euler's equation, Energy equation, Saint Venant equation, classification of partial differential equations.

NUMERICAL TECHNIQUES FOR SOLUTION OF PARTIAL DIFFERENTIAL EQUATION (18 Hours)
Review of linear algebra, solution of simultaneous linear algebraic equations-matrix inversion, solvers-direct methods, elimination methods, ill conditioned systems, Gauss-Seidel method, successive over relaxation method, Finite difference method, Finite element method, Finite volume method

ENGINEERING APPLICATIONS (16 Hours)
Application to water resources problems in open channel flows, Pressure Flow, ground water flows, and unsaturated flows through porous media.

[Total Hours: 45 Hours]

3. References:

1. Gerald, C.F., and Wheatley, P.O., "Applied Numerical Analysis", Pearson Education India, 2007 (Seventh Edition)
2. Choudhary, M. H., "Open Channel Flows", Springer, 2007 (Second Edition).
3. Abbott, M. B., "Computational Hydraulics", Pitman Publishing House, 1979.

4. Cunge, J. A., Holly, F. M., Verway, A., “Practical Aspects of Computational River Hydraulics”, Pitman Publishing House, 1980.
5. Pinder, G., and Gray, W. G., “Finite Element Simulation in Surface and Subsurface Hydrology”, Academic Press, New York, 1997.
6. Hoffman, D. H., “Numerical Methods for Engineers and Scientists”, CRC Press, Boca Raton, 2001 (Second Edition)

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	1	2	3	1
CO2	3	2	1	2	3	1
CO3	3	1	2	2	3	1
CO4	3	1	2	3	2	1
CO5	3	1	2	3	2	1

CEWR215

Core Elective-3 and 4: CLIMATE CHANGE STUDIES

L	T	P	Credit
3	0	0	3

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Understand basics of weather, climate, climate variability, climate change and its impact
CO2	Describe various layers of atmosphere, heat balance of earth atmosphere system, variation of temperature and soil temperature, thermal time and thermal extremes and carbon cycle
CO3	Elaborate the extreme climate events and modelling of climate change
CO4	Apply statistical methods in hydro-climatology
CO5	Study impact and mitigation measures

2. Syllabus

INTRODUCTION **(04 Hours)**
Hydrological cycle, Green house effect, Weather, Climate, Climate variability, ENSO, IOD and climate change, Impacts of climate change, Sources of data for climate studies.

FUNDAMENTALS OF CLIMATE CHANGE STUDY **(10 Hours)**
Overview of earth's atmosphere, Layers of atmosphere, Temperature, radiation and variation; Heat-balance of earth atmosphere system, Temporal variation of air temperature, Temperature change in soil, Thermal time and temperature extremes, Carbon cycle, Urban heat island.

EXTREME CLIMATE EVENTS **(05 Hours)**
Floods, Cloud burst, Droughts and Drought indicators, Heat waves, Sea level Rise, Compound Extremes.

CLIMATE CHANGE **(06 Hours)**
Introduction, Causes of climate change, Modelling of climate change, General circulation models, RCM, IPCC scenarios.

STATISTICAL METHODS IN HYDRO-CLIMATOLOGY **(08 Hours)**
Trend analysis, Empirical orthogonal functions, Principal component analysis, Canonical correlation, Statistical downscaling.

IMPACT AND MITIGATION MEASURES **(12 Hours)**

Regional Information on climate Change, observed impacts from climate change, vulnerability and exposure of ecosystems and people, risk in near term (2021-2040), mid to long term risks (2041-2100), complex, compound and cascading risks and impacts of temporary overshoot, Mitigation and development pathways in near to mid-term, long term mitigation pathways, mitigation potential across sectors and systems, societal aspects of mitigation and mitigation in the context of sustainable development.

[Total Hours: 45 Hours]

3. References:

1. Bonan, G. B., "Ecological Climatology : Concepts and Applications", Cambridge University Press, 2008.
2. Storch H.V., and ZweirsF.w., "Statistical Analysis in Climatic Research", Cambridge, 1999. 999.
3. Mujumdar,P.P., and Kumar,D.N., "Floods in Changing Climate", Cambridge university press,2012 (First Edition).
4. McGuffie, K., and Henderson-Sellers, "A Climate Modeling Primer", Wiley, 2005 (Third Edition).
5. IPCC (2022) "Sixth Assessment Reports", Intergovernmental Panel on Climate Change, Geneva.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	1	2	1	1	1
CO2	1	1	2	1	1	1
CO3	1	1	2	1	1	1
CO4	3	2	3	2	2	2
CO5	1	1	2	1	1	1

CEWR216

Core Elective-3 and 4: WATER INFRASTRUCTURE IN SMART CITIES

L	T	P	Credit
3	0	0	3

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Analyse Water Distribution Network
CO2	Design Storm Water Network
CO3	Plan Sewerage and Effluent Collection Network
CO4	Apply the integrated flood management practices
CO5	Resolve the water related infrastructure layout conflicts.

2. Syllabus

URBAN WATER ISSUES (03 Hours)
Water requirement, water availability, water budget, water balance, Zero liquid discharge concept and implementation, Preparation of DPR.

WATER DISTRIBUTION NETWORK (08 Hours)
Life cycle cost of distribution network, design and analysis of water distribution network.

SEWERAGE AND EFFLUENT COLLECTION NETWORK (09 Hours)
Design of sewerage network, Design of effluent collection network

STORM WATER DRAINAGE NETWORK AND INTEGRATED FLOOD MANAGEMENT (11 Hours)
Selection of IDF, Design of Storm water network with innovation, Flood plain delineation, integrated flood management practice, Low Impact Development.

Urban Lakes and Reservoirs(4 Hours)
Quality and Quantity Assessment, rehabilitation and restoration of urban water bodies

SMART WATER MANAGEMENT TECHNOLOGIES AND CONFLICTS (10 Hours)
Human-machine interface, wireless sensors, remote monitoring solution, SCADA, Priority of water related infrastructure, conflicts, resolution of conflicts based on hydraulics of flow

[Total Hours: 45 Hours]

3. References:

1. Rossmiller,R.L., “Storm water design for sustainable development”, Mc.Graw-Hill Education, 2013(First Edition)
2. Bhave,P.R., and Gupta R., “Analysis of Water Distribution Networks”, Alpha Science International Ltd.2006
3. Central Public Health and Environmental Engineering Organization (CPHEEO), Manual on Sewerage and Sewage Treatment Part A: Engineering, Ministry of Housing and Urban Affairs (Previously known as Ministry of Urban Development), New Delhi
4. Central Public Health and Environmental Engineering Organization (CPHEEO), Manual on Water Supply and Treatment, Ministry of Housing and Urban Affairs (Previously known as Ministry of Urban Development), New Delhi
5. Central Public Health and Environmental Engineering Organization). Ministry of Housing and Urban Affairs, Government of India, Manual on Storm Water Drainage System, Volume I-PART A: Engineering Design, Ministry of Housing and Urban Affairs (Previously known as Ministry of Urban Development), New Delhi

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	2	2	3	1
CO2	3	1	2	2	3	1
CO3	3	1	2	2	3	1
CO4	3	2	1	3	2	1
CO5	3	2	1	3	1	2

CEWR203

Computational Hydraulics Laboratory

L	T	P	Credit
0	0	4	2

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Synthesize acquired theoretical knowledge through simulation of open channel flow.
CO2	Simulate the computationally the hydrologic system.
CO3	Integrate the hydrologic and hydraulic system through computer simulation.
CO4	Analyse the water distribution system.
CO5	Optimize the reservoir operation through simulation.

2. Syllabus

1. Analysis of steady state water surface profile using HEC-RAS. **(07 hours)**
2. Analysis of unsteady state flood wave using HEC-RAS. **(09 hours)**
3. Hydrologic modelling of catchment using HEC-HMS. **(07 hours)**
4. Integration of hydrologic (HEC-HMS) and hydraulic models (HEC-RAS). (**09 shours)**
5. Water Distribution network analysis using LOOP. **(07 hours)**
6. Water distribution network analysis using WaterGEMs. **(07 hours)**
7. Water hammer analysis using Bentley Hammer. **(07 hours)**
8. Reservoir optimization through linear programming solution using LINGO. **(07 hours)**

[Total Hours: 60 Hours]

3. References:

1. USAEC (US Army Corps of Engineers), HEC-RAS River Analysis System Hydraulic Reference Manual Ver. 5.0 (2016)
2. USAEC (US Army Corps of Engineers) , HEC-HMS Users Manual (2022)
3. LINGO the modeling language and optimizer, user guide, 2011, Chicago.
4. Water GemsV8i, User's Guide, 2017.
5. Hammer V8i, User's Guide, 2017.

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	2	3	2	1
CO2	3	1	2	3	2	1
CO3	3	1	2	3	2	1
CO4	3	1	2	3	2	1
CO5	3	1	2	3	2	1

CEWR204

Hydraulic Engineering Laboratory-II

L	T	P	Credit
0	0	4	2

1. Course Outcomes (COs)

At the end of the Course the students will be able to:

CO1	Synthesize acquired theoretical knowledge with experimental observations for mobile bed channels.
CO2	Estimate experimentally the submergence characteristics of flow measuring structures in open channels.
CO3	Simulate experimentally hydraulic transients.
CO4	Measure experimentally the hydraulic conductivity and cone of depression for an unconfined aquifer
CO5	Demonstrate the fresh water – soil water interface

2. Syllabus

1. Measurement of discharge using Venturi flume for free and submerged flow conditions. **(06 hours)**
2. Measurement of discharge using Broad-crested weir for free and submerged conditions. **(06 hours)**
3. Incipient motion of sediments in mobile boundary channel. **(06 hours)**
4. Flow through porous media using ground water flow unit. **(06 hours)**
5. Measurements of bed shear stress by Preston tube. **(06 hours)**
6. Seepage analysis of earthen dam using electrical analogy. **(06 hours)**
7. Water Hammer Pressure and Surge tank Analysis. **(06 hours)**
8. Cavitation demonstration and analysis. **(06 hours)**
9. Measurement of soil moisture using tensiometer. **(06 hours)**
10. Hele-Shaw apparatus to study fresh water – soil water interface. **(06 hours)**

[Total Hours: 60 Hours]

3 References:

Asawa, G. L., "Laboratory Work in Hydraulic Engineering", New Age International Private Limited, 2016.

4 CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	2	1
CO2	1	2	3	3	2	1
CO3	3	1	2	3	2	1
CO4	3	1	2	3	2	1
CO5	3	1	2	3	2	1

SEMESTER – III

CEWR301

Dissertation (Preliminaries)

L	T	P	Credit
0	0	-	14

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Identify and investigate problems related to water resources.
CO2	Conduct the comprehensive literature review.
CO3	Identify research gap and decide objectives of research work.
CO4	Propose a methodology for solving the identified problem.
CO5	Plan experimental and/or numerical investigation to meet the objective.

2. Syllabus **(560 Hours)**

Dissertation Preliminaries should clearly identify the goals/objectives and scope of the dissertation work taken up by the student. Details of data identification and field surveys should be clearly highlighted. The study approach and literature review should be discussed. A report shall be submitted at the end of the semester, which shall be assessed.

[Total Hours: 560 hours]

3. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	2	1	1	2
CO2	2	2	3	2	2	2
CO3	2	1	2	2	1	1
CO4	2	2	3	2	2	2
CO5	2	1	2	2	2	2

SEMESTER – IV

CEWR401	**L**	**T**	**P**	**Credit**
Dissertation	**0**	**0**	**-**	**20**

---

1. Course Outcomes (COs)

At the end of the course the students will be able to:s

CO1	Examine the preliminary results and possible modifications in proposed methodology.
CO2	Conduct extensive analytical / modelling / experimental / field work.
CO3	Propose an effective sustainable solution for the identified problem.
CO4	Analyse the data with advanced tools and synthesize the outcomes.
CO5	Prepare comprehensive dissertation report.

2. Syllabus **(800 Hours)**

Develop model for experimental or computer programme using advanced tools for analysis and arrive the results. Obtain the result of the work carried out, discuss the results, infer the conclusions from the results with respect to the subject and report preparation.

Discuss the research work, infer the conclusions and submit the dissertation.

The dissertation report shall be submitted at the end of the semester, which shall be assessed as per the guidelines fixed by the Hon'ble Senate of the Institute.

(Total Hours: 800 hours)

3. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	2	1	1	1
CO2	2	1	2	2	2	1
CO3	2	2	3	2	2	1
CO4	3	2	3	3	3	2
CO5	2	3	3	2	2	2