# Teaching and Examination Schemes with Syllabus

of

# Master of Technology
# in
# (Civil) Water Resources Engineering

(Effective 2022-23)

(Approved by the SEC of Senate dated August 8, 2022)



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

# Vision and Mission of the Institute

## Vision

To be one of the leading Technical Institutes disseminating globally acceptable education, effective industrial training and relevant research output.

## Mission

To be a globally accepted centre of excellence in technical education catalyzing absorption, innovation, diffusion and transfer of high technologies resulting in enhanced quality for all the stake holders.

# Vision and Mission of the Department

**Vision**

To be a global centre of excellence for creating competent professionals in Civil Engineering.

**Mission**

• To provide excellent education producing technically competent, globally employable civil engineers who will be leaders in the chosen field.

• To undertake research in conventional and advanced technologies fulfilling the needs and challenges of modern society.

• To provide consultancy services and develop partnerships with society, industry and public organizations.

• To organize seminar, conferences, symposia and continuing education programmes for academic and field community.

# Foreword

The post graduate course in Water resources Engineering is established in 1995.The section has well trained and experienced full time professors who impart the technical knowledge of Water Resources Engineering to the UG and PG students of the department. The section has produced not only UG and PG students but also significant number of doctoral students who are well placed in academics, government organization and some are practicing consultants.

The section has well equipped UG and PG laboratories to carry out numerical and experimental research work and meeting the academic requirement of UG and PG students. The post graduate course in Water Resources Engineering is designed to meet the present and future challenges of Water Resources fraternity. In the modern era of computers, the applications of number of software's in solving complex water resources problems are included in the syllabi. Applications of HEC-RAS, HEC-HMS, MIKE-11, MIKE FLOOD, Sewer Gems, Water Gems, LINGO, WIN QIP, Storm CAD, ERDAS, ARC GIS etc. are part of the learning process for UG, PG and PhD students. The students get opportunity to interact the practical environment through Professional Training during summer vacation. Their communication skill and presentation ability is developed through inclusion of seminar and graduate reports in the course of study. During their dissertation work students get chance to carry out in depth study of specific Water Resources related topic. The site visits and expert lectures organized from time to time is an integral part of the study. Apart from full time PhD students, many part time research scholars are also pursuing their doctoral in the Water Resources Engineering section.

The Water Resources Engineering faculties are is also actively involved in a number of sponsored research projects sanctioned through organization like Ministry of Jal Shakti, Science and Engineering Research Board,Department of Science and Technology, All India Council for Technical Education, Indian Space Research Organisation etc. The section offers consultancy services to the government and private consultants in water resources and hydraulic engineering fields. The faculty members also have good number of publications in International and National Journals and authored few books. The section organizes national conferences, workshops and short term training programmes on regular basis. The course curriculum is revised regularly by conducting workshops wherein experts from IISc, IITs, NITs, Government Organizations like Sardar Sarovar Narmada Nigam Limited, Central Water Commission, and State Irrigation Department give their valuable suggestions.

# Programme Educational Objectives (PEOs)

Graduates of PG Programme in Civil Engineering Specialization Water Resources Engineering shall be able to:

- PEO-1 Provide environment-friendly solutions for the hydrologic and hydraulic engineering problems in consonance with societal needs and available means.
- PEO-2 Apply modelling and computational techniques for analyzing water resources systems.
- PEO-3 Predict future trends of climatic variables at river basin scales.

# Programme Outcomes (POs)

The outcomes of the Master of Technology programme in Civil Engineering Specialization in Water Resources Engineering are:

- PO-1  An ability to independently carry out research/investigation and development work to solve practical problems in the field of water resources engineering.
- PO-2  An ability to write and present a substantial technical report/document on water resources engineering.
- PO-3 Students should be able to demonstrate a degree of mastery in water resources engineering. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

# Programme Specific Outcomes (PSOs)

Graduates of the programme in Civil Engineering specialization in Water Resources Engineering will

- PSO-1: Be able to effectively use acquired knowledge to formulate and implement cost effective as well as sustainable solutions in water resources engineering.

- PSO-2: Exhibit their knowledge in water resources engineering to plan and manage water resources projects as an individual/team member or leader serving the society ethically.

- PSO-3: Continue their self-learning and pursue research in relevant local, regional, and global water resources engineering field.

# Teaching Scheme

## M.Tech. in (Civil Engineering) with Specialization as Water Resources Engineering

## SEMESTER – I

| Sr. No. | Course | Code | Teaching Scheme Hours per week | | | Credit | Examination Scheme | | | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | | Theory | Tutorial | Practical | |
| 1 | Advanced Fluid Mechanics (Core-1) | CEWR101 | 3 | 1 | 0 | 4 | 100 | 25 | - | 125 |
| 2 | Free Surface Flow (Core-2) | CEWR102 | 3 | 1 | 0 | 4 | 100 | 25 | - | 125 |
| 3 | Advanced Hydrologic Analysis and Design (Core-3) | CEWR103 | 3 | 1 | 0 | 4 | 100 | 25 | - | 125 |
| 4 | Any one subject out of the list of core electives for Semester I (Core Elective 1) | | 3 | 0 | 0 | 3 | 100 | - | - | 100 |
| 5 | Any one subject out of the list of core electives for Semester I (Core Elective 2) | | 3 | 0 | 0 | 3 | 100 | - | - | 100 |
| 6 | Computational Techniques in Water Resources Engineering Laboratory | CEWR104 | 0 | 0 | 4 | 2 | - | - | 100 (40+60) * ** | 100 |
| 7 | Hydraulic Engineering Laboratory-I | CEWR105 | 0 | 0 | 4 | 2 | - | - | 100 (40+60) * ** | 100 |
| | | Total | 15 | 3 | 8 | 22 | 500 | 75 | 200 | 775 |

### List of Core Electives for Semester I

CEWR110 Computational Techniques in Water Resources Engineering
CEWR111 FloodControlandRiverTrainingWorks
CEWR112 IrrigationandDrainageSystemsEngineering
CEWR113 IntegratedWatershedManagement
CEWR114 Stochastic Hydrology
CEWR115 Water Supply Distribution Systems

## Total Contact Hours/week=26            Total Credits=22

* Internal Evaluation

**External Evaluation

# SEMESTER – II

| Sr. No. | Course | Code | Teaching Scheme Hours per week | | | Credit | Examination Scheme | | | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | | Theory | Tutorial | Practical | |
| 1 | Geospatial Techniques for Water Resources Engineering (Core-4) | CEWR201 | 3 | 0 | 2 | 4 | 100 | - | 50 (20+30) * ** | 150 |
| 2 | Water Resources Systems Engineering (Core-5) | CEWR202 | 3 | 1 | 0 | 4 | 100 | 25 | - | 125 |
| 3 | Any one subject out of the list of core electives for Semester II (Core Elective 3) | | 3 | 0 | 0 | 3 | 100 | - | - | 100 |
| 4 | Any one subject out of the list of core electives for Semester II (Core Elective 4) | | 3 | 0 | 0 | 3 | 100 | - | - | 100 |
| 5 | Institute Elective-1 | | 3 | 0 | 0 | 3 | 100 | - | - | 100 |
| 6 | Computational Hydraulics Laboratory | CEWR203 | 0 | 0 | 4 | 2 | - | - | 100 (40+60) * ** | 100 |
| 7 | Hydraulic Engineering Laboratory-II | CEWR204 | 0 | 0 | 4 | 2 | - | - | 100 (40+60) * ** | 100 |
| | | Total | 15 | 1 | 10 | 21 | 500 | 25 | 250 | 775 |

**Total Contact Hours/week=26**      **Total Credits=21**

**List of Core Electives for Semester-II**
CEWR210 Advanced Hydraulic Structures
CEWR211 Hydraulics of Alluvial Rivers
CEWR212 Hydropower Engineering
CEWR213 Ground Water Engineering
CEWR214 Computational Hydraulics
CEWR215 Climate Change Studies
CEWR216 Water Infrastructure in Smart Cities
**Institute Elective 1**
CEWR215 Climate Change Studies [#]
CEWR216 Water Infrastructure in Smart Cities[#]
CECS230 AI/ML Based Applications in Civil Engineering

# other than students of Post-graduation programme in Water Resources Engineering. Not as Institute Elective 1 for Water Resources Engineering students.

*  Internal Evaluation

**External Evaluation

## SEMESTER – III

| Sr. No. | Course | Code | Teaching Scheme Hours per week | | | Credit | Examination Scheme | | | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | | Theory | Internal | Practical | |
| 1 | Seminar | CEWR301 | 0 | 0 | 4 | **2** | - | 40 * | 60 ** | 100 |
| 2 | Professional Training## | CEWR302 | 0 | 0 | 0 | **2** | - | 40 * | 60 ** | 100 |
| 3 | Dissertation Preliminaries | CEWR303 | - | - | 12 | **6** | - | 80 * | 120 ** | 200 |
| | | **Total** | **0** | **0** | **16** | **10** | | **160** | **240** | **400** |

## = summer training during summer vacation

**Total Contact Hours/week=16**          **Total Credits=10**

\*   Internal Evaluation

\* \*   External Evaluation

## SEMESTER – IV

| Sr. No. | Course | Code | Teaching Scheme Hours per week | | | Credit | Examination Scheme | | | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | | Theory | Internal | Practical | |
| 1 | Dissertation | CEWR401 | - | - | 24 | 12 | - | 160 | 240 | 400 |
| | | **Total** | **-** | **-** | **24** | **12** | **-** | **-** | **-** | **400** |

**Total Credits for M. Tech.:65 (Range: 62-68)**

\*   Internal Evaluation

\*\*External Evaluation

TOTAL CREDIT: 22+21+10+12=65

TOTALHOURS:26+26+16+24=92

**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** (08Hours)

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 | L | T | P | Credit |
|---|---|---|---|---|
| **Core 2:FREE SURFACE FLOW** | **3** | **1** | **0** | **4** |

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## 1. <u>CourseOutcomes (COs)</u>

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 unsteadinessand 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 |

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## 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** **(08Hours)**
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 $\phi$-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 drainagesystem, 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    |

| | **L** | **T** | **P** | **Credit** |
|---|---|---|---|---|
| **CEWR110** | | | | |
| **Core Elective 1 and 2: Computational Techniques in** | **3** | **0** | **0** | **3** |
| **Water Resources Engineering** | | | | |

## 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., "Hydro informatics :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

### 2.  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    |

| | L | T | P | Credit |
|---|---|---|---|---|
| **CEWR111** **Core Elective 1 and 2: FLOOD CONTROL & RIVER TRAINING WORKS** | 3 | 0 | 0 | 3 |

## 1. Course Outcomes (COs)

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

| CO1 | Assess morphological behaviour 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 | L | T | P | Credit |
|---|---|---|---|---|
| **Core Elective 1 and 2: IRRIGATION AND DRAINAGE SYSTEMS ENGINEERING** | **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.

## 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    |

**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    |

| | L | T | P | Credit |
|---|---|---|---|---|
| **CEWR114**<br>**Core Elective 1 and 2:STOCHASTIC HYDROLOGY** | 3 | 0 | 0 | 3 |

## 1. <u>Course Outcomes</u>

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 | Fitprobability distribution to hydrologic data |

## 2. <u>Syllabus</u>

**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 | L | T | P | Credit |
|---|---|---|---|---|
| **Core Elective 1 and 2: Water Supply Distribution Systems** | 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 | L | T | P | Credit |
|---------|---|---|---|--------|
| **COMPUTATIONAL TECHNIQUES IN WATER RESOURCES ENGINEERING LABORATORY** | 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.  <u>References:</u>

1. Abbott, M. B., "Hydro informatics: 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 Vijayalakshmi Pai, G.A., "Neural Networks, Fuzzy Logic and Genetic Algorithms-Synthesis and Applications", PHI Learning Pvt. Ltd., New Delhi, 2013

### 4.  <u>CO-PO-PSO_Mapping</u>

|     | 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 |

| | L | T | P | Credit |
|---|---|---|---|---|
| **CEWR105** | **0** | **0** | **4** | **2** |
| **Hydraulic Engineering Laboratory – I** | | | | |

## 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 $\alpha$ and $\beta$. **(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. <u>References:</u>

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

## 4. <u>CO-PO-PSO_Mapping</u>

|     | 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 | L | T | P | Credit |
|---|---|---|---|---|
| **Core 4: GEOSPATIAL TECHNIQUES FOR WATER RESOURCES ENGINEERING** | **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]**

| | L | T | P | Credit |
|---|---|---|---|---|
| **CEWR202** <br> **Core 5: WATER RESOURCES SYSTEMS** <br> **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    |

| | **L** | **T** | **P** | **Credit** |
|---|---|---|---|---|
| **CEWR210** <br> **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. <u>References:</u>

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. <u>CO-PO-PSO_Mapping</u>

|     | 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 | | L | T | P | Credit |
|---------|---|---|---|---|--------|
| **Core Elective 3 and 4: Hydropower Engineering** | | 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    |

**CEWR213**

**Core Elective 3 and 4: Ground Water Hydrology**

| L | T | P | Credit |
|---|---|---|--------|
| 3 | 0 | 0 | 3 |

## 1. <u>Course Objectives</u>

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. <u>Syllabus</u>

**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    |

| | L | T | P | Credit |
|---|---|---|---|---|
| **CEWR214** | **3** | **0** | **0** | **3** |
| **Core Elective 3 and 4: COMPUTATIONAL** | | | | |
| **HYDRAULICS** | | | | |

## 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 | L | T | P | Credit |
|---|---|---|---|---|
| **Core Elective-3 and 4: CLIMATE CHANGE STUDIES** | 3 | 0 | 0 | 3 |

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## 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, Greenhouse 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 Zweirs F.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 | Analyze 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

## 3. <u>References:</u>

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. <u>CO-PO-PSO Mapping</u>

|     | 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 |

| | **L** | **T** | **P** | **Credit** |
|---|---|---|---|---|
| **CEWR215** | 3 | 0 | 0 | 3 |
| **Institute Elective 1 : CLIMATE CHANGE STUDIES** | | | | |

## 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, Greenhouse 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. <u>References</u>

1. Bonan, G. B., "Ecological Climatology: Concepts and Applications", Cambridge University Press, 2008.
2. Storch H.V., and Zweirs F.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. <u>CO-PO-PSO Mapping</u>

|     | 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**

**Institute Elective 1: WATER INFRASTRUCTURE IN SMART CITIES**

| L | T | P | Credit |
|---|---|---|--------|
| 3 | 0 | 0 | 3 |

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## 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

## 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

## 5. 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 |

**CEEC730**

**Institute Elective 1 : AI/ML BASED APPPLICATIONS IN CIVIL 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 | Comprehend the basic principles of artificial intelligence (AI) and machine learning (ML) algorithms. |
|-----|-----|
| CO2 | Understanding Data collection & management tools & techniques for AI/ML application to Civil Engineering. |
| CO3 | Derive the need and benefits of using AI/ML algorithms for developing applications in Civil Engineering using big-data analysis. |
| CO4 | Solve the real-life problems in Civil Engineering using real-time data collection and big-data analysis involving AI/ML tools. |
| CO5 | Evaluate the performance of different AI/ML algorithms towards a given application in civil engineering. |

## 2. Syllabus

**Introduction to Machine Learning** (8 hours)

**Machine Learning Basics**: Data Collection, Data Management, Big data, taxonomy of machine learning algorithms, **Supervised Learning:** Classification – Bayesian Classifier, K-nearest Neighbours, Regression- Linear Regression, Multivariate Regression, Logistic regression. Support Vector Machine (SVM) Algorithm. **Unsupervised Learning:** Clustering- K-means clustering algorithm and Hierarchical clustering algorithm. **Reinforcement Learning:** Q-Learning algorithm.

**Data Collection Apparatuses** (8 hours)

Type of data sources, Types of data, Types of sensors, Edge-devices, Introduction to microcontrollers, data communication protocols, Cloud storage and cloud computing, Local server setup, Cloud server setup, Introduction to Python, Introduction to Django server, Database setup.

**Applications in Civil Engineering** (15 hours)

Intelligent Transportation systems, smart mobility, shared mobility, Mobility as a Service (MaaS), Real-time data monitoring, Structural health monitoring, Fire resistance evaluation of structures, automation in water resource management, Water quality monitoring, water distribution system monitoring, air and noise pollution monitoring, Rainfall-runoff modelling, Climate change monitoring, Soil

liquefaction, Forecasting foundation related parameters, Building occupancy modelling, Building information modelling, Energy demand prediction, Predictive maintenance of equipment, roads and buildings

**APPLICATION PART I: Data Collection and Management**     **(7 hours)**

Image processing for real time applications in Civil Engineering**,** Description of available database across specialisations**,** Selection of sensors and microcontroller, Integration of sensors with Edge-device, Programming of Edge-devices, Programming of server in Django framework, Collection of sensor data and storing to Database, Cloud computing

**APPLICATION PART II:  Big Data Analysis**     **(7 hours)**

Selecting the appropriate ML algorithm for analysis, Data Processing, Analysing the importance of each variable in decision making,andAnalysis of processed data.

**[Total Hours: 45 Hours]**

3. **References:**

1. *Machine Learning using Python,* by Manaranjan Pradhan, U Dinesh Kumar, Wiley.
2. *A Primer on Machine Learning Applications in Civil Engineering,* by Deka P C, Taylor & Francis.
3. *Structural Health Monitoring: A Machine Learning Perspective,* by Charles R. Farrar, Keith Worden, Wiley.
4. *Building Blocks for IoT Analytics,* By John Soldatos, Athens Information Technology, Greece, River Publishers.
5. *Django - The Easy Way (2nd Edition)*, By Samuli Natri.
6. *The Django Book (Release 2.0)*, By Adrian Holovaty, Jacob Kaplan-Moss, et al., 2013.
7. *Benjamin J. R., Cornell C. A., Probability Statistics and Decision for Civil Engineers, McGraw-Hill, 1970.*
8. Simon P. Washington, Matthew G. Karlaftis, Fred, Mannering L., *Statistical and econometric methods for transportation data analysis*, CRC Press, Second Edition, 2010.
9. Richard A. Johnson, Dean W. Wichern, *Applied Multivariate Statistical Analysis*, Prentice Hall, 1992.

4. **Other Material:**

1. *Arduino-ESP32 (Release 2.0.2)*, Espressif, 2022.

## 5. **CO-PO-PSO Mapping**

|     | PO1 | PO2 | PO3 | PSO1 | PSO2 | PSO3 |
|-----|-----|-----|-----|------|------|------|
| CO1 | 3   | 3   | 3   | 3    | 3    | 3    |
| CO2 | 3   | 2   | 3   | 3    | 2    | 2    |

| | | | | | | |
|---|---|---|---|---|---|---|
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 |
| CO4 | 3 | 3 | 3 | 3 | 2 | 3 |
| CO5 | 3 | 2 | 3 | 3 | 3 | 3 |

| CEWR203 | L | T | P | Credit |
|---|---|---|---|---|
| **Computational Hydraulics Laboratory** | **0** | **0** | **4** | **2** |

## 1. <u>Course Outcomes (COs)</u>

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. <u>Syllabus</u>

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. <u>References:</u>

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. <u>CO-PO-PSO Mapping</u>

|  | 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 |

| | **L** | **T** | **P** | **Credit** |
|---|---|---|---|---|
| **CEWR204** | **0** | **0** | **4** | **2** |
| **Hydraulic Engineering Laboratory-II** | | | | |

## 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)**

# 3 <u>References:</u>

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

# 4 <u>CO-PO-PSO Mapping</u>

|  | 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**

**Seminar**

| L | T | P | C |
|---|---|---|---|
| 0 | 0 | 4 | 2 |

## 1. Course Outcomes (COs)

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

| CO1 | Outline the advanced knowledge of the topic through literature review |
|---|---|
| CO2 | Use of audio-visual aids for effective presentation. |
| CO3 | Prepare an effective written technical report intended for technical oral presentation. |
| CO4 | Respond appropriately to the critique on the report and presentation. |
| CO5 | Compile the Seminar Report. |

## 2. Syllabus                                                            (60 Hours)

- Seminar on three specific topics based on subjects of the semester are to be prepared in consultation with the faculty advisor and to be submitted in duplicate typed on A4 sheet. One of the report is to be presented on scheduled date. Minimum one expert lecture be arranged on specific relevant topic by expert from academic institute, industry or relevant field.

- Seminar are assessed by the P.G. Section at Departmental Level.

**[Total Hours: 60 hours]**

## 3. CO-PO-PSO_Mapping

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

| | | L | T | P | Credit |
|---|---|---|---|---|---|
| **CEWR302** | | 0 | 0 | 0 | 2 |
| **Professional Training** | | | | | |

## 1. Course Outcomes (COs)

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

| CO1 | Conduct onsite project visit for comprehensive field exposure |
|---|---|
| CO2 | Obtain practical knowhow about processes in the field |
| CO3 | Appraise the work culture and environment of industry |
| CO4 | Identify the water resources engineering related problems. |
| CO5 | Compile the professional training report. |

## 2. Syllabus:

About six to eight weeks professional training on major Water Resources Engineering projects be carried out at the National/State/Local Government/Private sectors, after the second Semester Examination and before opening of the Third Semester. The report is to be submitted by the student duly certificated by the project organization.

Operation of Professional Training

The handling of the summer training will be carried out by PG Incharge WRE in consultation with Professor in charge (T&P) of institute. The Professional Training will be evaluated during Third Semester.

## 3. CO-PO-PSO Mappings

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

## SEMESTER – III

**CEWR303**

**Dissertation (Preliminaries)**

| L | T | P | Credit |
|---|---|---|--------|
| 0 | 0 | 12 | 6 |

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## 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                                          (180 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: 180 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**

**Dissertation**

| L | T | P | Credit |
|---|---|---|--------|
| 0 | 0 | 24 | 12 |

## 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                                   (360 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: 360 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 |