INTEGRATED WATERSHED HYDROLOGICAL MODELLING			
Course Code	**1MCWR201**	Scheme	2026
Type of Course	**Professional Elective Course**	Semester	II
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	120 (42:0:28:50)	SEE Marks	50
Credits	4	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course outcome (Course Skill Set):

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

1. CO1: Explain the fundamentals of watershed hydrology, watershed management principles, and sustainable resource management practices.
2. CO2: Apply mechanical and vegetative interventions for soil and moisture conservation and evaluate watershed treatment measures.
3. CO3: Utilize physical and digital modelling tools, GIS, RS, and DSS techniques for watershed analysis and management.
4. CO4: Analyze watershed data using GIS-based methods for planning, monitoring, prioritization, and decision-making.
5. CO5: Develop integrated watershed management plans incorporating hydrological, environmental, socio-economic, and sustainability considerations.

Module-1

Introduction to watershed hydrology

- Introduction to watershed hydrology, its management and agricultural sustainability issues; need of integrated watershed management in India; delineation of watersheds.
- Hydrology of watershed systems; estimation of surface runoff and sediment yields; effect of precipitation and hydro-climatic conditions on watershed systems
- Watershed erosion processes and its prevention; instrumentation and measurement of watershed management indicators

Linked COs: CO1 **Number of Hours: 8 hrs**

Module-2

Mechanical and vegetative interventions in watershed

- Mechanical and vegetative interventions for prevention of erosion and moisture conservation in watersheds; water quality issues in watersheds; optimal land use planning in watersheds.
- Management of saline and alkaline soils
- Heuristics and indigenous technical knowledge (ITKs) in watershed management
- Watershed associations and groups in villages of India; Government policies, acts and schemes on watershed management

Linked COs: CO2 **Number of Hours: 9 hrs**

Module-3

Physical Modeling concepts

- Physical Modeling, Concepts, scale factor, practical considerations, model study

- Digital Elevation Models: Creation of digital elevation models, Visualization, Mapping of water and environmental features, Watersheds, streams and aquifers delineation.
- Use of GPS, GIS, RS and Decision Support Systems (DSS) in watershed management; technologies for rain-fed farming; socio-economic evaluation of the watershed management projects.

Linked COs: CO3 **Number of Hours: 9 hrs**

Module-4

Watershed Modeling

- Digitization, Soil and land use mapping, Map algebra, Terrain analysis, Presentation of modeling results, Analysis to generate new information and knowledge
- Dissemination of new information and knowledge, GIS as a decision support tool, use of Water Evaluation, Analysis and Planning (WEAP) in spatial domain

Linked COs: CO4 **Number of Hours: 8 hrs**

Module-5

Modelling with GIS tools

- Modelling with GIS tools with 1 Dimensional models, Use of ArcHydro, HEC GeoHMS, Geo-RAS, HMS & RR modelling, RAS and river analysis, GeoWEPP
- Watershed modelling with GIS- quasi distributed models, Distributed model, WMS, GSSHA, ArcSWAT for land use change scenario analysis
- Analyzing DEM for watershed analysis, XPSWMM and urban flooding, flood hazard, risk map generation.

Linked COs: CO5, CO6 **Number of Hours: 8 hrs**

PRACTICAL COMPONENTS OF IPCC

1. Watershed delineation using Digital Elevation Model (DEM).
2. Estimation of surface runoff using the SCS Curve Number (SCS-CN) method.
3. Preparation of land use and land cover (LULC) map using GIS.
4. Soil erosion assessment using the Universal Soil Loss Equation (USLE).
5. Generation of DEM, slope, aspect, and contour maps.
6. Watershed mapping using GPS and Remote Sensing data.
7. Digitization of watershed features and preparation of thematic maps.
8. Watershed planning using the WEAP model.
9. Rainfall–runoff modeling using HEC-HMS.
10. Flood hazard mapping using HEC-RAS and GIS.

Suggested Learning Resources

Textbooks

1. Tideman, E. M., "Watershed Management", Omega Scientific Publishers, New Delhi, 2002
2. Suresh Rao, Soil and Water Conservation Practices, Standard Publishers, 2003.
3. J. V. S Murthy, Watershed Management, New Age International Publishers, 1998.

Reference Books

1. Heathcote, I. W., "Integrated Watershed Management" Springer.
2. Strahler, A. H.,"Modern physical geography", John Wiley & Sons, 1991.
3. V.V. N. Murthy, Land and Water Management, Kalyani Publishers, 1994.

Web links and Video Lectures (e-Resources)

1. https://archive.nptel.ac.in/courses/105/101/105101010/
2. https://bbsbec.edu.in/wp-content/uploads/2020/01/watershed-management-8AG-PPT.pdf
3. https://cfpub.epa.gov/watertrain/pdf/modules/watershed_management.pdf

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Watershed characterization:** Delineation of watershed, analysis of topography, land use, soil, and drainage characteristics using GIS tools.	24
2	**Hydrological data analysis:** Collection and processing of rainfall, runoff, evapotranspiration, and streamflow data for watershed assessment.	24
3	**Hydrological modelling and simulation:** Application of watershed models for runoff estimation, water balance studies, and scenario analysis.	24

4	**Result interpretation and reporting:** Calibration, validation, performance evaluation of models, and preparation of technical reports.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	Study research papers, technical manuals, and case studies on watershed hydrology, hydrological modelling, soil erosion, groundwater recharge, and watershed management.	24
2	Complete a MOOC/online course on SWAT, HEC-HMS, GIS, Remote Sensing, or hydrological modelling for watershed management.	24
3	Prepare a technical report or presentation on watershed delineation, rainfall–runoff modelling, land-use change analysis, or integrated watershed management using GIS-based hydrological models.	24

Sample rubrics for TW activities:

Criteria	**4 - Excellent**	**3 - Good**	**2 - Satisfactory**	**1 - Needs Improvement**
Problem Understanding	Clearly defines watershed issues and modelling objectives.	Good understanding with minor gaps.	Basic understanding of watershed processes.	Problem definition is unclear.
Data and Method	Appropriate hydrological data and modelling methods used accurately.	Suitable data and methods with minor errors.	Limited data or partially suitable methods.	Inadequate data and methods.
Analysis	Accurate analysis and interpretation of watershed modelling results.	Good analysis with minor errors.	Basic analysis with limited interpretation.	Poor or incomplete analysis.
Recommendations	Practical and sustainable watershed management solutions suggested.	Relevant recommendations with minor limitations.	General recommendations.	Weak or unsupported recommendations.
Presentation	Well-organized and professional presentation.	Clear presentation with minor issues.	Adequate presentation.	Poorly organized presentation.

HYDROLOGIC SYSTEMS ANALYSIS & SIMULATIONS			
Course Code	**1MCWR202**	Scheme	2026
Type of Course	Professional Core Course	Semester	II
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course outcome (Course Skill Set):

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

1. CO1: Apply systems analysis concepts to formulate hydrologic and water resources problems.
2. CO2: Apply linear programming techniques for optimal water allocation and reservoir operation.
3. CO3: Analyze hydrologic systems using dynamic programming for multi-stage decision-making problems.
4. CO4: Apply advanced optimization techniques (non-linear and multi-objective) for complex water resources planning problems.
5. CO5: Develop and evaluate simulation models using appropriate software tools for hydrologic system analysis and decision-making.

Module-1

Introduction to Systems Analysis in Hydrology

- Systems approach in water resources engineering
- Components of hydrologic systems
- Deterministic and stochastic systems
- Introduction to modelling and simulation concepts
- Overview of optimization in hydrologic systems

Linked COs: CO1 **Number of Hours: 8 hrs**

Module-2

Linear Programming in Hydrologic Systems

- Formulation of Linear Programming (LP) problems
- Graphical and Simplex methods
- Duality in LP
- Applications in water allocation and reservoir operation
- Multipurpose reservoir planning (single and multi-reservoir systems)
- Reservoir yield models (complete and implicit stochastic models)

Linked COs: CO2 **Number of Hours: 9 hrs**

Module-3

Dynamic Programming Applications

- Principles of Dynamic Programming (DP)
- Bellman's principle of optimality
- Water allocation among multiple users

- Canal water distribution problems
- Controlled and uncontrolled inventory models
- Applications in reservoir operation and planning

Linked COs: CO3 **Number of Hours: 9 hrs**

Module-4

Advanced Optimization Techniques

- Non-linear programming (NLP): unconstrained and constrained problems
- Kuhn–Tucker (KKT) conditions
- Multi-objective optimization in hydrologic systems
- Applications: capacity expansion, sequencing, and system optimization
- Reservoir planning using controlled output and inventory DP models

Linked COs: CO4 **Number of Hours: 8 hrs**

Module-5

Simulation and Software Applications

- Simulation techniques in hydrologic systems
- Reservoir operation using simulation models
- Integration of simulation and optimization
- Application of software tools (LINDO, MATLAB, Python)
- Case studies in hydrologic systems analysis

Linked COs: CO5 **Number of Hours: 8 hrs**

Suggested Learning Resources

Textbooks

1. K. Subramanya, Engineering Hydrology, 4th Edition, Tata McGraw Hill Education, New Delhi, 2013.
2. S. L. Dingman, Physical Hydrology, 2nd Edition, Prentice Hall, Upper Saddle River, New Jersey, 2008.
3. D. K. Todd and L. W. Mays, Groundwater Hydrology, 3rd Edition, John Wiley & Sons, New York, 2005.
4. L. W. Mays, Water Resources Engineering, John Wiley & Sons, New York, 2001.
5. G. M. Hornberger, Elements of Physical Hydrology, The Johns Hopkins University Press, Baltimore, 1998.

Reference Books

1. V. P. Singh, Elementary Hydrology, Prentice Hall of India, New Delhi, 1994.
2. V. T. Chow, D. R. Maidment and L. W. Mays, Applied Hydrology, McGraw-Hill, New York, 1988.
3. R. K. Linsley, M. A. Kohler and J. L. H. Paulhus, Hydrology for Engineers, 3rd Edition, McGraw-Hill, New York, 1982.
4. R. W. Herschy (Ed.), Hydrometry: Principles and Practices, John Wiley & Sons, New York, 1978.
5. V. T. Chow (Ed.), Handbook of Applied Hydrology, McGraw-Hill, New York, 1964.

Web links and Video Lectures (e-Resources)

1. USGS Water Resources – Hydrologic data, streamflow analysis, and watershed studies.
2. HEC-HMS Tutorials – Hydrologic modeling, rainfall-runoff simulation, and flood forecasting.
3. SWAT Model Resources – Watershed assessment, water quality, and hydrologic simulations.
4. NASA Earthdata and Global Hydrology Datasets – Remote sensing data for hydrologic analysis.
5. NPTEL/SWAYAM Courses on Hydrology, Watershed Management, Hydrologic Modeling, and Water Resources Systems.

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Hydrological data analysis exercise:** Analyze rainfall, streamflow, evaporation, and groundwater data. Compute statistical parameters and identify trends.	24
2	**Rainfall–runoff modeling study:** Develop and calibrate a rainfall–runoff model for a selected watershed using hydrologic simulation software.	24
3	**Watershed analysis and flood simulation assignment:** Delineate a watershed and simulate flood hydrographs under different rainfall scenarios.	24
4	**Hydrologic system planning mini-project:** Propose a water resources management strategy incorporating reservoir operation, flood control, or drought mitigation measures.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours**

		/ Semester
1	Study hydrologic modeling concepts and prepare a report on watershed processes and hydrologic cycle components.	24
2	Learn and practice simulation using software such as HEC-HMS, SWAT, or MIKE HYDRO and document the workflow.	24
3	Complete a MOOC/NPTEL course module on Hydrology, Watershed Management, or Water Resources Systems and submit a summary report.	24

Sample rubrics for TW activities:

Criteria	**4 - Excellent**	**3 - Good**	**2 - Satisfactory**	**1 - Needs Improvement**
Problem understanding	Clear understanding of the hydrologic problem with well-defined objectives and assumptions.	Mostly clear understanding with minor gaps in objectives or assumptions.	Basic understanding with limited clarity on the hydrologic problem.	Poorly defined hydrologic problem and objectives.
Data and method	Appropriate hydrologic data selection and sound simulation methodology.	Mostly appropriate data and methods with minor issues.	Limited data usage or partially appropriate methodology.	Inadequate data selection or incorrect methodology.
Analysis	Robust analysis of simulation results with accurate interpretation of hydrologic processes.	Generally sound analysis with minor errors in interpretation.	Partial analysis with gaps in interpretation of results.	Weak or incorrect analysis of simulation outcomes.
Recommendations	Strong, feasible, and watershed-specific recommendations based on simulation results.	Relevant recommendations with minor limitations.	Generic recommendations with limited connection to results.	Incomplete, impractical, or unsupported recommendations.
Presentation	Well-organized, technically sound, and professional presentation of findings.	Good organization with minor technical or formatting issues.	Acceptable presentation but lacks clarity or consistency.	Poorly presented and difficult to follow.

GROUNDWATER FLOW & AQUIFER MANAGEMENT			
Course Code	**1MCWR203**	Scheme	2026
Type of Course	Professional Core Course	Semester	II
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course outcome (Course Skill Set):

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

1. CO1 : To understand background and utilization of ground water.
2. CO2 : To understand ground water movement.
3. CO3 : To applications of ground water well hydraulics.
4. CO4 : To Analyze the water wells by different methods.
5. CO5 : To Analyze the ground water levels fluctuations.

Module-1

Introduction

- Scope, historical background, utilization of groundwater, groundwater in the hydrologic cycle, origin and age of groundwater. Rock properties affecting groundwater: Geologic formations as aquifers, types of aquifers, porosity
- Soil classification, specific surface, vertical distribution of groundwater, zone of aeration, zone of saturation, specific retention, specific yield, storage coefficient, springs.

Linked COs: CO1 **Number of Hours: 8 hrs**

Module-2

Groundwater movement

- Darcy's law and its validity, intrinsic permeability, hydraulic conductivity, transmissivity, techniques for determination of hydraulic conductivity
- Groundwater flow rates, flow nets, flow in relations to ground water contours, flow across a water table, flow across, a hydraulic conductivity boundary, dispersion, and general flow equations in rectangular and radial co-ordinations.

Linked COs: CO2 **Number of Hours: 9 hrs**

Module-3

Groundwater well hydraulics

- Steady unidirectional flow steady radial flow to a well, unsteady radial flow in a confined aquifer, unsteady radial flow in an unconfined aquifer
- unsteady radial flow in a leaky aquifer, well flow near aquifer boundaries, multiple well systems, partially penetrating wells, characteristic well losses, specific capacity and well efficiency
- planning.

Linked COs: CO3 **Number of Hours: 9 hrs**

Module-4

Water wells

- Surface geophysical methods - electrical resistivity method - seismic method - subsurface investigation - test drilling - resistivity logging - application of remote sensing method.
- Test holes and well log; methods for constructing shallow wells and deep wells, well completion, pumping equipment for wells, protection of wells, well rehabilitation, infiltration galleries, horizontal pipes, collector wells.

Linked COs: CO4 **Number of Hours: 8 hrs**

Module-5

Groundwater Levels and Environmental Influences

- Time variations of levels, stream flow and groundwater levels, fluctuations due to evapotranspiration, meteorological phenomena urbanization, earthquakes, external loads and land subsidence.

Linked COs: CO5. **Number of Hours: 8 hrs**

Suggested Learning Resources

Textbooks

1. Groundwater Manual", "A water resources Technical Publication", U.S. Department of the interior - Edition. 1985.
2. Karanth, K. R.A text book "Ground Water Assessment: Development and Management" Tata McGraw
3. Raghunath H.M , "A text book on Groundwater", III Edition, New age. Publications,2007.
4. Todd, D.K., "Groundwater Hydrology", John Wiley & Sons edition, 1980.

Reference Books

1. Groundwater Manual", "A water resources Technical Publication", U.S. Department of the interior - Edition. 1985.

Web links and Video Lectures (e-Resources)

1. NPTEL
2. https://easyengineering.net/hydrology-principles-analysis-design-by-raghunath-nw/
3. https://ebbaybrinmacake.tk/a1d332ace26b2eb230adf24c13d519971GUtR3VnlkR-mna0R08zsPv98gtvR5FJeiPYzg2

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Groundwater data analysis exercise:** Analyze groundwater level, pumping test, recharge, and water quality data. Determine aquifer parameters and identify temporal and spatial trends.	24
2	**Aquifer characterization study:** Evaluate aquifer properties such as transmissivity, hydraulic conductivity, storativity, and specific yield using field and laboratory data.	24
3	**Groundwater flow modeling assignment:** Develop and calibrate a groundwater flow model for a selected aquifer using suitable simulation software and assess the impact of pumping and recharge scenarios.	24
4	**Aquifer management mini-project:** Propose a sustainable groundwater management plan incorporating artificial recharge, conjunctive use, groundwater quality protection, and demand management measures.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	Study groundwater occurrence, aquifer systems, recharge mechanisms, and groundwater flow principles; prepare a technical report.	24
2	Learn and practice groundwater modeling using software such as MODFLOW, Visual MODFLOW, or GMS and document the workflow and outcomes.	24
3	Complete a MOOC/NPTEL course module on Groundwater Hydrology, Aquifer Management, or Hydrogeology and submit a summary report highlighting key learning outcomes.	24

Sample rubrics for TW activities:

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
Problem understanding	Demonstrates comprehensive understanding of groundwater flow processes, aquifer characteristics, and management objectives.	Demonstrates good understanding with minor gaps in concepts or objectives.	Shows basic understanding of groundwater and aquifer management concepts.	Demonstrates limited understanding of groundwater flow and aquifer systems.
Data and method	Appropriately selects and applies hydrogeological data, analytical techniques, and groundwater modeling methods.	Uses suitable data and methods with minor errors or omissions.	Uses limited data and partially appropriate methods.	Inadequate data selection and inappropriate methodology.
Analysis	Accurately analyzes groundwater flow behavior, aquifer parameters, and simulation results with sound interpretation.	Provides good analysis with minor interpretation errors.	Conducts basic analysis with limited interpretation of results.	Analysis is incomplete, inaccurate, or poorly interpreted.
Recommendations	Provides practical, sustainable, and technically sound aquifer management strategies based on analysis.	Provides relevant recommendations with minor limitations.	Recommendations are general and only partially supported by results.	Recommendations are weak, impractical, or unsupported by analysis.
Presentation	Presents findings clearly with excellent organization, technical accuracy, and professional documentation.	Presentation is clear and organized with minor issues.	Presentation is adequate but lacks clarity or technical detail.	Presentation is poorly organized, incomplete, or difficult to follow.

IRRIGATION SYSTEMS DESIGN & MICRO-IRRIGATION TECHNOLOGIES			
Course Code	**1MCWR204**	Scheme	2026
Type of Course	**Professional Core Course**	Semester	II
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course outcome (Course Skill Set):

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

1. CO1: To know various methods and advanced techniques of irrigation in India
2. CO2: To understand soil water movement in the root zone of agricultural crops
3. CO3: To know water requirement for various crops and to estimate the duration and frequency for irrigation.
4. CO4: Analyze the study water conveyance method and design
5. CO5: Analyze to know the various methods of land reclamation subjected to water logging and salinity.

Module-1

Irrigation Techniques

- Necessity of irrigation, Advantages and Disadvantages of irrigation, Types & Techniques of Irrigation including advanced techniques, Irrigation development after Independence, Present situation of irrigation in India, Future possibilities of Irrigation Development.
- Soil properties, Soil classification, Classification of soil water, Soil water constants, Importance of water in plant growth, Irrigation water quality, Functions of Irrigation Water, Soil-Moisture-Irrigation Relationship, Estimating depth and frequency of irrigation.
- Water requirements and irrigation planning, factors affecting irrigation interval, optimum. Utilization of Irrigation Water, Crop Seasons in India, Effect of Water Stress on Crops.

Linked COs: CO1 **Number of Hours: 8 hrs**

Module-2

Land preparations

- Farm Size, Importance of land preparations, Small-scale land levelling, Land Capability classification, The various classes and their characteristic, Significance of Land Capability Classification in Land use Planning
- Types of Agriculture based on its dependence on water, Irrigation Return Flow, Indian Agriculture, Modern agricultural revolution, Modern commercial agriculture, Structures in Irrigation Systems
- Modern Machines in Agriculture, Farm Hand Tools, Agricultural Machinery, Equipment and Tools.

Linked COs: CO2 **Number of Hours: 9 hrs**

Module-3

Crop categories

- Crop Seasons and Categories of Crops in India, Multiple Cropping, Hybrid Cropping, Crop Period, Base Period, Delta of a Crop, Duty, Duty-Delta-Base Period Relation

- Factors Affecting Duty, Irrigation Efficiencies, Determining Irrigation Requirement of Crops, Irrigation Scheduling.
- Consumptive use of Crops- Blanney-Criddle method, Thornthwait penman method, scope of computerization in irrigation.

Linked COs: CO3 **Number of Hours: 9 hrs**

Module-4

Computing the canals flow

Losses in water canals, Computing the capacity of canals, Canal networks, Typical cross sections of canal-Unlined and Lined. Balancing depth, Types of lined canals, Design of lined canals.

Linked COs: CO4 **Number of Hours: 8 hrs**

Module-5

Design of surface and subsurface drains

Causes for water logging and salinity, Impact of water logging and salinity, Design of surface and subsurface drains, Saline and alkaline lands reclamation and management of Salt affected lands.

Linked COs: CO5 **Number of Hours: 8 hrs**

Suggested Learning Resources

Textbooks

1. D. P. Loucks, J. R. Stedinger and D. A. Haith, Water Resources Systems Planning and Analysis, Prentice Hall Inc., New York, 1982.
2. M. C. Chaturvedi, Water Resources Systems Planning and Management, Tata McGraw-Hill Publishing Company, New Delhi, 1987.
3. W. A. Hall and J. A. Dracup, Water Resources Systems, Tata McGraw-Hill Publishing Company, New Delhi, 1975.

Reference Books

1. L. D. James and R. R. Lee, Economics of Water Resources Planning, McGraw-Hill Inc., New York, 1975.
2. E. Kuiper, Water Resources Development: Planning, Engineering and Economics, Butterworths, London, 1973.

Web links and Video Lectures (e-Resources)

1. NPTEL.
2. https://openlibrary.org/books/OL2163261M/Water_resources_systems_planning_and_management

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.
A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.
In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Irrigation water requirement analysis exercise:** Estimate crop water requirements, irrigation scheduling, and irrigation efficiencies for selected crops using climatic and soil data.	24
2	**Irrigation system design study:** Design surface, sprinkler, and drip irrigation systems for a selected command area considering crop, soil, and water source characteristics.	24
3	**Micro-irrigation performance evaluation assignment:** Analyze the hydraulic performance of drip and sprinkler systems, including emitter discharge, uniformity coefficient, and application efficiency.	24
4	**Irrigation management mini-project:** Develop an efficient irrigation plan incorporating micro-irrigation technologies, fertigation practices, and water conservation measures for sustainable agriculture.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	Study irrigation methods, crop water requirements, irrigation efficiencies, and micro-irrigation components; prepare a technical report.	24
2	Learn and practice the design and evaluation of drip and sprinkler irrigation systems using relevant software tools and document the workflow and outcomes.	24
3	Complete a MOOC/NPTEL course module on Irrigation Engineering, Micro-Irrigation Technologies, or Agricultural Water Management and submit a summary report highlighting key learning outcomes.	24

Sample rubrics for TW activities:

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
Problem Understanding	Clear understanding of irrigation design requirements and objectives.	Good understanding with minor gaps.	Basic understanding of concepts.	Limited understanding of the problem.
Data and Method	Appropriate data and design methods used accurately.	Suitable data and methods with minor errors.	Limited data or partially suitable methods.	Inadequate data and methods.
Analysis	Accurate analysis of irrigation system performance and results.	Good analysis with minor errors.	Basic analysis with limited interpretation.	Poor or incomplete analysis.
Recommendations	Practical and sustainable irrigation solutions suggested.	Relevant recommendations with minor limitations.	General recommendations.	Weak or unsupported recommendations.
Presentation	Well-organized and professional presentation.	Clear presentation with minor issues.	Adequate presentation.	Poorly organized presentation.

WATER POLICY AND GOVERNANCE & SDG-6			
Course Code	**1MCWR205A**	Scheme	2026
Type of Course	**Professional Elective Course**	Semester	II
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course outcome (Course Skill Set):

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

1. CO1: To know various methods and advanced techniques used in water pollution control, treatment and management.
2. CO2: To understand the water and industrial wastewater sampling and monitoring methods and techniques
3. CO3: To study the concept of water quality modelling approaches and wastewater monitoring planning and management.
4. CO4: To know various sustainable approaches for water and wastewater pollution control, treatment and management. Underrated Water Acts, laws, legislation.
5. CO5: To know the various recent trends, technique used for the water pollution control, treatment and management.

Module-1

Introduction and Industrial waste effects

- Definition of Water Pollution, Cause and Sources, and Consequences of Water Pollution and Remedial Measures. Wastewater characteristics, Nature of pollutants, Ground water pollution –Cause, Sources and its effects on environment and Remedial Measures.
- On Sewage Treatment Plant and Receiving Water Bodies, Present Scenario of River and Lake Pollution in India.
- Self-Purification of Streams. Effluent Standards and Stream Standards.

Field Visits: Water And Wastewater Treatment Plant. (To Understand The Process And Treatment Of Wastewater)

Linked COs: CO1 **Number of Hours: 8 hrs**

Module-2

Wastewater Sampling and monitoring

- Existing approaches of control/abatement of water quality degradation, Concept of Material Balance-Methods, wastewater Sampling methods and techniques, Sampling Procedure, Stages and Preservation. Natural methods of wastewater Disposal.
- Definition and concept of river and lake water quality monitoring and management. Water quality assessment of lake and river water, Wastewater Monitoring in stream, river and lake.
- Types and Methods of wastewater Monitoring, water and wastewater monitoring system in treatment plants, Stages Involved in Monitoring process, Equipment's used in Monitoring Process. Concept of Biomonitoring.
- DO and BOD in streams, Transformation and transport processes, Oxygen Transfer, Turbulent mixing, Flow Augmentation.

Linked COs: CO2 **Number of Hours: 9 hrs**

Module-3

Point and Non-Point Source of Pollution

- NPDES Storm water program, Nutrient pollution. National Estuary Program (NEP), Water Quality Standards, Storm water Pollution, Green Storm water Management. Polluted Runoff.
- Models used for Surface and Ground Water quality Modelling. – Concept of Modelling, Stages, General Flow chart of Modelling process, types of Models, Application, key points, Limitations.

Linked COs: CO3 **Number of Hours: 9 hrs**

Module-4

Water Acts, laws, legislation

- Importance of Water laws & legislation – Water Act (1986), National Water Policy (CPCB). Water quality objectives and standards. Riparian rights, Groundwater ownership, Environmental Protection Law, Water pollution control acts and, Legislation in India, Control Acts, EPA, NPDES, TSCA, RCRA, drinking water and wastewater resilience.
- Sustainable water and wastewater management, Sustainable approaches for water treatment and wastewater control, treatment and management, Sustainable water infrastructure. Sustainable rural wastewater management.

Linked COs: CO4 **Number of Hours: 8 hrs**

Module-5

Industrial Wastewater Pollutants

Sources, Process, Characterization, Treatment of Wastewater And Effects of Industrial Effluents on Environment**.** Industries: Fertilizer, Tannery, Pulp, and Paper Mill, Dairy, Cane Sugar, Textile, Distillery and Brewery.

Field Visits: Local Industries (To Understand The Process And Treatment Of Wastewater)

Linked COs: CO5 **Number of Hours: 8 hrs**

Suggested Learning Resources

Textbooks

1. H.S. Peavy, D.R. Rowe, G. Tchobanoglous. "Environmental Engineering", McgrowHill International Edition, 1st Edition, 2020.
2. Dr. B.C. Punmia, Arun Kumar Jain, Ashok Kumar Jain. Environmental Engineering, II, Laxmi Publications Pvt Limited, 2022
3. Dr. B.C. Punmia, Arun Kumar Jain, Ashok Kumar Jain, Wastewater Engineering, Laxmi Publications Pvt Limited, 2020.
4. Marcello Benedini, George Tsakiris, "Water Quality Modelling for Rivers and Streams", 2013.

Reference Books

1. Environmental Protection Agency (EPA) guidelines, regulations, manual.
2. Steven C. Chapra, "Surface Water-Quality Modeling,"· 2008
3. Satinder Ahuja · "Monitoring Water Quality: Pollution Assessment, Analysis, and Remediation", Publisher: Elsevier Science, 2013
4. Daoliang Li, Shuangyin Liu, "Water Quality Monitoring and Management, Basis, Technology and Case Studies" · 2018

5. P.K. Goel, "Water Pollution Causes, Effects and Control", · publisher: New Age International 2006

Web links and Video Lectures (e-Resources)

1. NPTEL.
2. https://archive.nptel.ac.in/courses/105/102/105102159/

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Review of water policies and governance frameworks:** Study national and international water policies, institutional arrangements, and regulatory mechanisms.	24
2	**Assessment of SDG–6 indicators:** Analyze targets and indicators related to clean water and sanitation using case studies and available datasets.	24
3	**Case studies on water governance:** Evaluate water resource management practices, stakeholder participation, and policy implementation challenges.	24

4	**Policy analysis and reporting:** Assess policy effectiveness, identify gaps, and prepare recommendations aligned with SDG–6 objectives.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	Study reports, policy documents, and research papers related to water governance, water security, and SDG–6.	24
2	Complete a MOOC/online course on sustainable development, water governance, public policy, or integrated water resources management.	24
3	Prepare a presentation or technical report on SDG–6 achievements, challenges, and future strategies for sustainable water management.	24

Sample rubrics for TW activities:

Criteria	**4 - Excellent**	**3 - Good**	**2 - Satisfactory**	**1 - Needs Improvement**
Problem Understanding	Clearly defines water policy, governance issues, and SDG-6 objectives.	Good understanding with minor gaps.	Basic understanding of concepts.	Problem definition is unclear.
Data and Method	Appropriate policy documents, data, and analytical methods used effectively.	Suitable data and methods with minor errors.	Limited data or partially suitable methods.	Inadequate data and methods.
Analysis	Accurate analysis of water governance challenges and SDG-6 indicators.	Good analysis with minor errors.	Basic analysis with limited interpretation.	Poor or incomplete analysis.
Recommendations	Practical and sustainable policy recommendations aligned with SDG-6.	Relevant recommendations with minor limitations.	General recommendations.	Weak or unsupported recommendations.
Presentation	Well-organized and professional presentation.	Clear presentation with minor issues.	Adequate presentation.	Poorly organized presentation.

WATERSHED MODELLING USING SWAT/HEC-HMS			
Course Code	**11MCWR205B**	Scheme	2026
Type of Course	**Professional Elective Course**	Semester	II
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course outcome (Course Skill Set):

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

1. CO1: Apply concepts of water resources modeling, including mathematical and system-based approaches, to solve practical engineering problems.
2. CO2: Apply principles of physical modeling, including scale factors and similitude, for analysis and interpretation of hydraulic systems.
3. CO3: Apply techniques for creating and analyzing Digital Elevation Models (DEM) to delineate watersheds, streams, and aquifers.
4. CO4: Analyze GIS-based tools and methods for watershed modeling, terrain analysis, and decision support in water resources planning.
5. CO5: Analyze hydrological and hydraulic models.

Module-1

Introduction

Modeling in Water Resources: Need, objectives and scope of water resources modelling; role of modelling in planning, design and management of water resources systems. **Types of Models:** Physical, mathematical, empirical, conceptual, deterministic, stochastic, lumped, distributed and semi-distributed models; simulation and optimization models. **Mathematical Models:** Formulation of governing equations, continuity and momentum principles, analytical and numerical approaches, model calibration, validation and sensitivity analysis. **Systems Concept:** System components, boundaries, inputs, outputs, feedback mechanisms, simulation, optimization and decision support in water resources planning. **Practical Models:** Selection of appropriate models, data requirements, limitations and applications; overview of SWAT, HEC-HMS, HEC-RAS, WEAP and other hydrological modelling tools.

Linked COs: CO1 **Number of Hours: 8 hrs**

Module-2

Modeling concepts

Physical Modeling: Principles, prototype and model relationship, applications in hydraulic engineering. **Similarity Concepts:** Geometric, kinematic and dynamic similarity; dimensional analysis using Buckingham π theorem. **Scale Factors:** Scale ratios for length, area, volume, velocity, discharge, force, pressure and time. **Similitude Laws:** Froude, Reynolds, Weber and Euler similitude criteria and their applications. **Practical Considerations:** Model construction, instrumentation, boundary conditions, calibration, verification, measurement techniques, interpretation of results, sources of errors and limitations. **Model Studies:** Applications of physical models in spillways, dams, rivers, barrages, bridge hydraulics, coastal structures and energy dissipators.

Linked COs: CO2 **Number of Hours: 9 hrs**

Module-3

Digital Elevation Models

Digital Elevation Models (DEM): Concepts, characteristics and applications; DEM generation from contour maps, GPS, LiDAR, SRTM, ASTER and CartoDEM datasets. **DEM Processing:** Interpolation techniques, sink filling, flow direction, flow accumulation and stream extraction. **Visualization:** Hillshade generation, contour mapping, three-dimensional terrain visualization, slope, aspect, curvature and relief analysis. **Mapping of Water and Environmental Features:** Identification and mapping of rivers, streams, lakes, reservoirs, wetlands, floodplains and groundwater recharge zones using DEM and GIS. **Watershed, Stream and Aquifer Delineation:** Watershed boundary extraction, drainage network generation, stream ordering, sub-watershed delineation, morphometric analysis, aquifer mapping and groundwater potential assessment using DEM and GIS techniques.

Linked COs: CO3 **Number of Hours: 9 hrs**

Module-4

Watershed Modeling

Digitization, Soil and land use mapping, Map algebra, Terrain analysis, Presentation of modeling results, Analysis to generate new information and knowledge, Dissemination of new information and knowledge, GIS as a decision support tool, use of Water Evaluation, Analysis and Planning (WEAP) in spatial domain.

Linked COs: CO4 **Number of Hours: 8 hrs**

Module-5

Modelling with GIS

Modelling with GIS tools with 1 Dimensional models, Use of ArcHydro, HEC GeoHMS, Geo-RAS, HMS & RR modelling, RAS and river analysis, GeoWEPP, Watershed modelling with GIS- quasi distributed models, Distributed model, WMS, GSSHA, ArcSWAT for land use change scenario analysis, Analyzing DEM for watershed analysis, XPSWMM and urban flooding, flood hazard, risk map generation.

Linked COs: CO5, CO6 **Number of Hours: 8 hrs**

Suggested Learning Resources

Textbooks

1. T. M. Lillesand and R. W. Kiefer, Remote Sensing and Image Interpretation, 4th Edition, John Wiley & Sons, Inc., New York, 2000.
2. P. A. Burrough and R. A. McDonnell, Principles of Geographical Information Systems, Oxford University Press, Oxford, UK, 1998.
3. R. N. Sankhua, Practical GIS in Water Resources, National Water Academy, Pune, 2004.
4. U.S. Army Corps of Engineers, Hydrologic Engineering Center (HEC) Technical Manuals and User Manuals, U.S. Army Corps of Engineers, Davis, California, 2010.
5. Rudra Pratap, MATLAB: A Practical Introduction to Programming and Problem Solving, Oxford University Press, New Delhi, 2010.

Reference Books

1. P. E. Black, Watershed Hydrology, 2nd ed. Boca Raton, FL, USA: CRC Press, 1996.
2. R. K. Frevert and G. O. Schwab, Soil and Water Conservation Engineering, New York, NY, USA: John Wiley & Sons, 1993.
3. K. N. Mutreja, Applied Hydrology, New Delhi, India: Tata McGraw-Hill Education, 1986.
4. R. Suresh, Soil and Water Conservation Engineering, 5th ed. New Delhi, India: Standard Publishers

Distributors, 2014.
5. J. G. Lyon, GIS for Water Resource and Watershed Management, Boca Raton, FL, USA: CRC Press, 2003.

Web links and Video Lectures (e-Resources)

1. SWAT+ Documentation Portal – https://swatplus.com/
2. SWAT+ Editor Documentation – https://swatpluseditor.readthedocs.io
3. Texas A&M SWAT Resources – https://swat.tamu.edu/
4. HEC-HMS Official Training Portal – https://www.hec.usace.army.mil/software/hec-hms/training.aspx
5. HEC-HMS Webinars and Tutorials – https://www.hec.usace.army.mil/training/webinars.aspx

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Watershed delineation and database preparation:** Delineate watershed boundaries and prepare DEM, land use, soil, and meteorological datasets using GIS tools.	24

2	**Model setup and input preparation:** Configure SWAT/HEC-HMS models, define basin parameters, and process hydrological input data.	24
3	**Simulation, calibration, and validation:** Perform rainfall-runoff simulations, calibrate model parameters, and validate model performance using observed data.	24
4	**Scenario analysis and report preparation:** Evaluate watershed management scenarios, interpret results, and prepare technical reports and presentations.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	Study SWAT and HEC-HMS user manuals, research papers, and watershed modelling case studies.	24
2	Complete online tutorials/MOOCs on GIS, SWAT, HEC-HMS, remote sensing, and hydrological modelling applications.	24
3	Prepare a technical presentation on watershed modelling applications for water resources planning and management.	24

Sample rubrics for TW activities:

Criteria	**4 - Excellent**	**3 - Good**	**2 - Satisfactory**	**1 - Needs Improvement**
Problem Understanding	Clearly defines watershed modelling objectives and study requirements.	Good understanding with minor gaps.	Basic understanding of watershed modelling concepts.	Problem definition is unclear.
Data and Method	Appropriate hydrological, meteorological, and spatial data used with correct modelling methodology.	Suitable data and methods with minor errors.	Limited data or partially suitable methods.	Inadequate data and methods.
Analysis	Accurate model calibration, validation, and interpretation of simulation results.	Good analysis with minor errors.	Basic analysis with limited interpretation.	Poor or incomplete analysis.
Recommendations	Practical watershed management recommendations based on model results.	Relevant recommendations with minor limitations.	General recommendations.	Weak or unsupported recommendations.
Presentation	Well-organized and professional	Clear presentation with minor issues.	Adequate presentation.	Poorly organized presentation.

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
	presentation.			

FLOOD HYDROLOGY AND RISK MANAGEMENT			
Course Code	**1MCWR205C**	Scheme	2026
Type of Course	**Professional Elective Course**	Semester	II
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course outcome (Course Skill Set):

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

1. CO1: Apply principles of flood hydrology to analyze rainfall–runoff processes, catchment characteristics, and design flood estimation methods.
2. CO2: Apply flood routing and hydraulic modelling techniques using tools such as HEC-RAS/MIKE FLOOD for simulation of flood behavior and inundation mapping.
3. CO3: Apply methods of flood hazard, vulnerability, and risk assessment using statistical analysis and mapping techniques.
4. CO4: Apply structural and non-structural flood management strategies, including urban flood control measures and nature-based solutions.
5. CO5: Apply modern tools and technologies such as GIS, remote sensing, decision support systems, and AI/ML for flood forecasting, analysis, and management.

Module-1

Fundamentals of Flood Hydrology

- Classification and causes of floods
- Catchment characteristics and extreme rainfall analysis
- Development of flood hydrographs and unit hydrograph theory
- Design flood estimation methods: empirical, statistical, rainfall–runoff

Linked COs: CO1 **Number of Hours: 8 hrs**

Module-2

Flood Modelling and Routing

- Flood routing: hydrologic (Muskingum, Puls) and hydraulic methods (Saint-Venant equations)
- 1D & 2D flood modelling using HEC-RAS, MIKE FLOOD
- Floodplain mapping using DEMs
- Model calibration and validation

Linked COs: CO2 **Number of Hours: 9 hrs**

Module-3

Flood Hazard, Vulnerability and Risk Assessment

- Concepts: hazard, exposure, vulnerability, risk
- Frequency analysis and probability distributions
- Hazard mapping (return period and scenario-based)
- Vulnerability assessment (socio-economic indicators)
- Risk quantification (deterministic and probabilistic approaches)

Linked COs: CO3 **Number of Hours: 9 hrs**

Module-4

Flood Risk Management and Urban Flooding

- Structural measures: embankments, reservoirs, channel improvements
- Non-structural measures: forecasting, warning systems, zoning, insurance
- Integrated Flood Management (IFM) and nature-based solutions
- Urban flooding: stormwater management, LID and SUDS concepts

Linked COs: CO4 **Number of Hours: 8 hrs**

Module-5

Policies, Technologies and Decision Support Systems

- Policies: NDMA, CWC, UNDRR frameworks, EU Flood Directive
- Case studies (national and international rivers)
- GIS and remote sensing in flood analysis
- Decision Support Systems (DSS) for flood management
- Emerging technologies: AI/ML, IoT, UAVs, digital twins

Linked COs: CO5 **Number of Hours: 8 hrs**

Suggested Learning Resources

Textbooks

1. Z. W. Kundzewicz, Flood Risk and Vulnerability: A Global Perspective, Springer, Dordrecht, 2012.
2. K. Smith and R. Ward, Floods: Physical Processes and Human Impacts, John Wiley & Sons (Wiley-Blackwell), Chichester, UK, 1998.
3. National Disaster Management Authority (NDMA), Guidelines on Management of Floods, Government of India, New Delhi, 2008.
4. H. Apel, A. H. Thieken, B. Merz and G. Blöschl, "Flood Risk Analysis: Concepts and Challenges," Natural Hazards, Vol. 49, No. 3, Springer, 2009.

Reference Books

1. Merz, B., Hall, J., Disse, M., and Schumann, A., “Flood Risk Management: Current Practice and Future Challenges,” Natural Hazards and Earth System Sciences, Vol. 10, No. 3, pp. 509–527, 2010.
2. Di Baldassarre, G., Kreibich, H., Vorogushyn, S., and Aerts, J. C. J. H., “Flood Risk in a Changing World,” Nature Climate Change, Vol. 8, pp. 781–786, 2018.
3. Jongman, B., “Effective Adaptation to Rising Flood Risk,” Nature Communications, Vol. 9, Article 1986, 2018.

Web links and Video Lectures (e-Resources)

1. NPTEL Video Course on Watershed Hydrology – IIT Kharagpur
2. NPTEL Video Course on Engineering Hydrology
3. HEC-RAS Training Webinars by USACE Hydrologic Engineering Center
4. HEC-HMS Modeling Tutorials on HEC-USACE YouTube Channel
5. Flood Risk Assessment and Floodplain Mapping using HEC-RAS and GIS (YouTube Tutorials)

Teaching-Learning Process (Innovative Delivery Methods):

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Assessment Structure (both CIE and SEE)

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Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Flood hydrological analysis:** Collection and analysis of rainfall, streamflow, and flood frequency data for estimating design floods.	24
2	**Flood modelling and mapping:** Application of hydrological and hydraulic models to simulate flood events and prepare flood inundation maps.	24
3	**Flood risk and vulnerability assessment:** Evaluation of flood hazards, exposure, vulnerability, and potential impacts on communities and infrastructure.	24
4	**Flood mitigation planning and reporting:** Assessment of structural and non-structural flood management measures and preparation of technical reports.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	Study research papers, flood management guidelines, and case studies on flood forecasting and risk assessment.	24
2	Complete a MOOC/online course on flood hydrology, disaster risk reduction, GIS, remote sensing, or hydraulic modelling.	24
3	Prepare a technical presentation or report on flood risk management strategies, early warning systems, and climate change impacts on floods.	24

Sample rubrics for TW activities:

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
Problem Understanding	Clearly defines flood hydrology and risk management objectives.	Good understanding with minor gaps.	Basic understanding of flood-related concepts.	Problem definition is unclear.
Data and Method	Appropriate hydrological, meteorological, and flood data used with correct methodology.	Suitable data and methods with minor errors.	Limited data or partially suitable methods.	Inadequate data and methods.
Analysis	Accurate analysis of flood frequency, routing, inundation, and risk assessment results.	Good analysis with minor errors.	Basic analysis with limited interpretation.	Poor or incomplete analysis.
Recommendations	Practical flood mitigation and risk management measures proposed.	Relevant recommendations with minor limitations.	General recommendations.	Weak or unsupported recommendations.
Presentation	Well-organized and professional presentation.	Clear presentation with minor issues.	Adequate presentation.	Poorly organized presentation.

HYDROPOWER & DAM ENGINEERING			
Course Code	**1MCWR205D**	Scheme	2026
Type of Course	**Professional Elective Course**	Semester	II
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course outcome (Course Skill Set):

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

1. CO1: Apply principles of flood hydrology to analyze rainfall–runoff processes, catchment characteristics, and design flood estimation methods.
2. CO2: Apply flood routing and hydraulic modelling techniques using tools such as HEC-RAS/MIKE FLOOD for simulation of flood behavior and inundation mapping.
3. CO3: Apply methods of flood hazard, vulnerability, and risk assessment using statistical analysis and mapping techniques.
4. CO4: Apply structural and non-structural flood management strategies, including urban flood control measures and nature-based solutions.
5. CO5: Apply modern tools and technologies such as GIS, remote sensing, decision support systems, and AI/ML for flood forecasting, analysis, and management.

Module-1

Introduction to Hydropower

- Introduction, sources of energy, role of hydropower in a power system, development of water power potential in India and the world, Features and characteristics of water power generation.
- Data requirement for assessment of waterpower potential-flow duration and mass curves, energy flow diagram, demand and prediction
- Types of Hydropower generation plants- site selection and Planning – Environmental Considerations and its layouts

Linked COs: CO1 **Number of Hours: 8 hrs**

Module-2

Components of hydropower

- Components of a hydropower structure- regulatory structures-intake structures –types, location, losses, air entrainment, anti-vortex device, air vent, fore bay, trash racks, power canals
- Tunnels, surge tanks, settling basins, anchor blanks, penstocks- classification, resonance in penstocks, design criteria, losses, anchor blocks, valves, bends and manifolds

Linked COs: CO2 **Number of Hours: 9 hrs**

Module-3

Hydraulic Design

- Tunnels- geometric and hydraulic design, water hammer and surges, surge tank- functions, type, design of surge tank, methods of surge analysis, channel surges
- Types of water power house- structural and geotechnical aspects of power house design, location, site and general arrangements, draft tubes, tail trace and their hydraulic design, draught and cooling towers, turbines - characteristics, hydraulics of turbines

Linked COs: CO3 **Number of Hours: 9 hrs**

Module-4

Turbines

cavitations, transients caused by turbine and foundations, pumps-efficiency and characteristics, generators, exciters, switchboard, transformers and other accessories Water retaining structures-Dams-Classifications, types, planning and investigation of reservoir and dam sites, reservoir capacity and regulation, reservoir silting, dam optimization, analysis and design of earthen and rock fill dams, internal seepage, stability and stress, settlement and deformation, foundation treatment, analysis for failure and safety

Linked COs: CO4 **Number of Hours: 8 hrs**

Module-5

Gravity Dams

Gravity dam - forces acting and criteria, elementary and practical profile, stability analysis, modes of failures, joints, seals, keys and galleries in gravity dams, spillways-types, location and design, energy dissipaters, dam break analysis, dam safety and hazard mitigation

Linked COs: CO5 **Number of Hours: 8 hrs**

Suggested Learning Resources

Textbooks

1. Barrows, H. K, "Water Power Engineering", Tata McGraw Hill Publishing Company Ltd, New Delhi, 2000.
2. Creager, W.P, Justin, J. D and Hinds J, "Engineering for dams", Nem Chand and Brothers, Roorkee ,1995.
3. Dandekar, M.M., and Sharma, K.N, "Water Power Engineering", Vikas Publishing House, New Delhi ,1994
4. Garg S. K, "Irrigation Engineering and Hydraulic Structures" Khanna Publishers, New Delhi, 1998.
5. Khatsuria, R. M, "Hydraulics of spillways and energy dissipaters", CRC Press, New Delhi, 2005.

Reference Books

1. Novak, P., Moffat, A.I.B., Nalluri, C., and Narayanan, R., Hydraulic Structures, 4th Edition, Taylor & Francis, London, 2017.
2. Punmia, B. C., Lal, P. B. B., and Jain, A. K., Irrigation and Water Power Engineering, Laxmi Publications, New Delhi, 2016.
3. Varshney, R. S., Gupta, S. C., and Gupta, R. L., Theory and Design of Irrigation Structures, Nem Chand & Bros., Roorkee, 2014.
4. Singh, B., Fundamentals of Irrigation Engineering, Nem Chand & Bros., Roorkee, 2009.
5. French, R. H., Open-Channel Hydraulics, McGraw-Hill International Editions, New York, 1985.

Web links and Video Lectures (e-Resources)

1. NPTEL
2. https://easyengineering.net/irrigation-engineering-and-hydraulic/
3. https://www.youtube.com/watch?v=y7Qv3lGr4B4&list=PL9RcWoqXmzaJJhCtjG2WIHS4QFRzhLfk5

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Dam planning and site assessment:** Study dam types, site selection criteria, reservoir characteristics, and hydropower potential assessment.	24
2	**Design of dam components and hydropower systems:** Analyze spillways, outlet works, penstocks, turbines, and power generation components.	24
3	**Hydrological and structural analysis:** Estimate design floods, reservoir routing, dam stability, and safety considerations using relevant methods and software tools.	24
4	**Dam safety evaluation and reporting:** Assess operational performance, environmental impacts, risk management measures, and prepare technical reports.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	Study research papers, dam safety guidelines, hydropower development reports, and case studies of major dams and hydropower projects.	24
2	Complete a MOOC/online course on dam engineering, hydropower systems, water resources planning, or hydraulic structures.	24
3	Prepare a technical presentation or report on sustainable hydropower development, dam safety management, and environmental considerations.	24

Sample rubrics for TW activities:

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
Problem Understanding	Clearly defines hydropower and dam engineering objectives and requirements.	Good understanding with minor gaps.	Basic understanding of hydropower and dam concepts.	Problem definition is unclear.
Data and Method	Appropriate hydrological, hydraulic, and structural data used with correct methodology.	Suitable data and methods with minor errors.	Limited data or partially suitable methods.	Inadequate data and methods.
Analysis	Accurate analysis of reservoir, dam, and hydropower system performance.	Good analysis with minor errors.	Basic analysis with limited interpretation.	Poor or incomplete analysis.
Recommendations	Practical and sustainable solutions for dam operation and hydropower development proposed.	Relevant recommendations with minor limitations.	General recommendations.	Weak or unsupported recommendations.
Presentation	Well-organized and professional presentation.	Clear presentation with minor issues.	Adequate presentation.	Poorly organized presentation.

RIVER HYDRAULICS AND WATER SUPPLY ENGINEERING			
Course Code	**1MCWR205E**	Scheme	2026
Type of Course	**Professional Elective Course**	Semester	II
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course outcome (Course Skill Set):

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

1. CO1: Explain the principles of river hydraulics, hydrological processes, and estimation of inflow, runoff, and outflow in river basins.
2. CO2: Apply hydraulic principles to analyze flow in pipes and open channels, including the estimation of head losses and discharge.
3. CO3: Apply the principles of water conveyance systems for the design of pipelines, pumping stations, and water distribution components.
4. CO4: Analyze reservoir storage requirements, storage techniques, and hydraulic structures such as weirs for water resources planning.
5. CO5: Design basic water supply and river hydraulic systems using appropriate engineering concepts, standards, and software tools.

Module-1

Hydrology and River Hydraulics

Introduction to river hydraulics and water supply systems; hydrologic cycle and watershed concepts; inflow, runoff, and outflow processes; estimation of rainfall, runoff, and streamflow; hydrographs, flow duration curves, and flood estimation; river characteristics and channel classification; applications of river hydraulics in water resources planning and management.

Linked COs: CO1 **Number of Hours: 8 hrs**

Module-2

Flow Through Pipes and Open Channels

Flow through pipes and open channels; continuity equation, Bernoulli's equation, and energy principles; major losses using the Darcy–Weisbach equation and minor losses in pipelines; Hydraulic Gradient Line (HGL) and Total Energy Line (TEL); measurement of discharge in pipes and open channels using Venturimeter, Orifice meter, and Pitot tube; analysis of flow characteristics in pipe and channel systems.

Linked COs: CO2 **Number of Hours: 9 hrs**

Module-3

Water Conveyance Systems

Design concepts of water transmission pipelines; selection of pipe materials and pipe sizing; hydraulic design of gravity and pumping mains; pumping stations including components, layout, design considerations, pump types, selection, efficiency, and operating characteristics; water distribution systems, network components, and design principles for efficient water conveyance.

Linked COs: CO3 **Number of Hours: 9 hrs**

Module-4

Reservoirs and Hydraulic Structures

Reservoir planning and classification; reservoir capacity estimation; storage techniques and reservoir operation; dead storage, live storage, and flood storage; introduction to dams and spillways; types of weirs, discharge equations, and applications; river control and diversion structures for water resources management.

Linked COs: CO4 **Number of Hours: 8 hrs**

Module-5

Water Supply System Design

Components of water supply systems; water demand estimation and population forecasting; hydraulic design concepts of water supply systems; design of transmission and distribution pipelines; design considerations for pumping stations and service reservoirs; introduction to hydraulic modelling using EPANET/WaterGEMS; sustainable and smart water supply systems for efficient water distribution.

Linked COs: CO5 **Number of Hours: 8 hrs**

Suggested Learning Resources

Textbooks

1. Larry W. Mays, "Water Resources Engineering"**,** 3rd Edition, John Wiley & Sons, Hoboken, New Jersey, 2024.
2. K. Subramanya, "Engineering Hydrology"**,** 6th Edition, McGraw Hill Education (India) Pvt. Ltd., New Delhi, 2024.
3. Christoph Rapp, "Hydraulics in Civil Engineering: A Course with Experiments and Open-Source Codes"**,** Springer Nature, Cham, Switzerland, 2024.

Reference Books

1. Ven Te Chow, David R. Maidment and Larry W. Mays, Applied Hydrology, McGraw-Hill Education, New York, Reprint Edition, 2010.
2. M. Hanif Chaudhry, Open-Channel Flow, 2nd Edition, Springer Science & Business Media, New York, 2008.
3. Larry W. Mays (Ed.), Water Resources Handbook, McGraw-Hill Education, New York, 1996.
4. R. K. Rajput, Fluid Mechanics and Hydraulic Machines, S. Chand Publishing, New Delhi, 2017.

Web links and Video Lectures (e-Resources)

1. NPTEL
2. https://easyengineering.net/irrigation-engineering-and-hydraulic/
3. https://www.hec.usace.army.mil/software/hec-ras/

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Hydrological analysis and river flow estimation:** Estimate rainfall, inflow, runoff, and streamflow using hydrographs and watershed data; analyze river characteristics and flow behavior.	24
2	**Pipeline and pumping system design:** Design water transmission pipelines, estimate major and minor losses, select pumps, and prepare the layout of a pumping station using relevant standards.	24
3	**Reservoir and hydraulic structure analysis:** Estimate reservoir capacity, evaluate storage techniques, analyze weirs for discharge measurement, and perform reservoir operation studies using appropriate methods and software tools.	24
4	**Water supply system planning and technical reporting:** Design a basic water supply network, evaluate system performance using hydraulic modeling tools (EPANET/WaterGEMS), and prepare a technical report with recommendations for sustainable water supply management.	24

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	Study research papers, technical manuals, IS codes, and case studies related to river hydraulics, hydrological analysis, reservoirs, water supply systems, pipeline design, and pumping stations.	24
2	Complete a MOOC/online course on engineering hydrology, river hydraulics, water supply engineering, open channel flow, hydraulic structures, or hydraulic modeling tools such as EPANET, HEC-HMS, or HEC-RAS.	24

3	Prepare a technical presentation or report on topics such as sustainable water supply systems, smart water distribution networks, flood management, reservoir operation, river basin management, or pipeline hydraulics using recent case studies.	**24**

Sample rubrics for TW activities:

Criteria	**4 – Excellent**	**3 – Good**	**2 – Satisfactory**	**1 – Needs Improvement**
Problem Understanding	Clearly defines the river hydraulics and water supply engineering problem, objectives, and design requirements.	Good understanding with minor gaps.	Basic understanding of river hydraulics and water supply concepts.	Problem definition is unclear.
Data and Method	Appropriate hydrological, hydraulic, and water supply data are collected and analyzed using suitable engineering methods, standards, and software tools.	Suitable data and methods with minor errors.	Limited data or partially suitable methods.	Inadequate data and inappropriate methods.
Analysis	Accurate analysis of runoff, pipeline hydraulics, reservoir storage, pumping systems, and water distribution networks with proper interpretation of results.	Good analysis with minor errors.	Basic analysis with limited interpretation.	Poor or incomplete analysis.
Recommendations	Practical, sustainable, and technically feasible recommendations for river management and water supply system design are proposed based on analysis.	Relevant recommendations with minor limitations.	General recommendations.	Weak or unsupported recommendations.
Presentation	Well-organized, technically sound, and professionally presented report with appropriate drawings, calculations, tables, and references.	Clear presentation with minor issues.	Adequate presentation.	Poorly organized presentation with insufficient technical details.

URBAN WATER SYSTEMS & SMART WATER GRIDS			
Course Code	**1MCWR206A**	Scheme	2026
Type of Course	**Professional Elective Course**	Semester	II
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course outcome (Course Skill Set):

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

1. CO1: To understand the types and characteristics of urban flooding.
2. CO2: To understand the key climate uncertainties and expected consequences of climate change.
3. CO3: To acquire the knowledge of urban water cycle, flood damages, loss of life estimation and flood risk maps.
4. CO4: To understand the concept of sustainable flood response, IFRM, SPR model, NIPP.
5. CO5: To know the application of SUDS systems and FFWRS

Module-1

Fundamentals

- Introduction: The influence of climate, causes of flooding, types of flooding, fluvial/pluvial flooding, principles of land use planning.
- Climate Change: Key uncertainties and Robust Findings: A review of the past, signs of change, Expected consequences.

Linked COs: CO1 **Number of Hours: 8 hrs**

Module-2

Hydrology of cities

- Hydrology of cities: Urban hydrological cycle, Land use & runoff
- Urban flood risk assessment, Tangible & intangible damages, Loss of life estimation in flood risk assessment, flood risk mapping**.**

Linked COs: CO2 **Number of Hours: 9 hrs**

Module-3

Responding to Flood Risk

- Responding to Flood Risk: Responses, Resilience, Vulnerability, Robustness & Sustainability, SPR Model, Confronting flood management with land use planning, Building types, infrastructure & public open spaces**.**

Linked COs: CO3 **Number of Hours: 9 hrs**

Module-4

Drainage systems

- Urban drainage systems: A historical perspective, Major & Minor flows, SUDS/LIDS, Practices in water sensitive urban design
- Enhancing coping & recover capacity: Flood forecasting warning and response, Emergency Planning, Management & Evacuation.

Linked COs: CO4 **Number of Hours: 8 hrs**

Module-5

Disaster mitigation & Management

- Modes of disaster management, primary & secondary data
- EIA of flood management structures, traffic management during floods, socio-economic studies
- Interdepartmental cooperation, Regional & global disaster mitigation measurement.

Linked COs: CO5 **Number of Hours: 8 hrs**

Suggested Learning Resources

Textbooks

1. Geiger.W.F., Marsalek.F., Rawls.W.J., and Zuidena.F.C., (Ed), manual on drainage in urbanized areas - Vol.I and Vol.II, UNESCO, 1987.
2. Hengeveld H. and C.DeVoch.t (Ed)., "Role of Water in Urban Ecology", 1982.
3. Martin P.Wanelista and Yousef A.Yousef., "Storm Water Management", John Wileyand sons, 1993.
4. Neil S.Grigg., "Urban Water Infrastructure planning, management and Operations", John Wiley and Sons, 1986.
5. Overtens D.E. and Meadows M.E., "Storm Water Modelling", Academic Press, New York, 1976.

Reference Books

1. Butler, D. and Davies, J.W.**,** Urban Drainage, 4th Edition, CRC Press, Boca Raton, 2018.
2. Akan, A.O. and Houghtalen, R.J.**,** Urban Hydrology, Hydraulics and Stormwater Quality: Engineering Applications and Computer Modeling, Wiley, New Jersey, 2003.
3. Chin, D.A.**,** Water-Resources Engineering, 4th Edition, Pearson Education, Boston, 2019.
4. Viessman, W., Lewis, G.L., and Knapp, J.W**.**, Introduction to Hydrology, 5th Edition, Pearson Education, New Delhi, 2008.
5. Mays, L.W.**,** Water Resources Engineering, 3rd Edition, John Wiley & Sons, Hoboken, 2019.

Web links and Video Lectures (e-Resources)

1. NPTEL – Urban Utilities Planning: Water Supply, Sanitation and Drainage **https://nptel.ac.in**
2. NPTEL – Urban Drainage System and Stormwater Management Lectures https://www.youtube.com/@nptelhrd
3. TU Delft OpenCourseWare – Urban Drainage and Water Management **https://ocw.tudelft.nl**
4. U.S. EPA – Stormwater Management and Green Infrastructure **https://www.epa.gov/green-infrastructure**
5. Central Public Health and Environmental Engineering Organisation (CPHEEO) Manuals **https://mohua.gov.in**

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):

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- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE

taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Urban water system assessment:** Study urban water supply networks, demand patterns, distribution systems, and service-level indicators.	24
2	**Smart water grid design and monitoring:** Analyze sensor technologies, IoT-based monitoring systems, SCADA applications, and real-time data acquisition.	24
3	**Water distribution modelling and analysis:** Develop and evaluate hydraulic models for network performance, leak detection, pressure management, and demand forecasting.	24
4	**Sustainable urban water management and reporting:** Assess water conservation measures, smart metering, integrated urban water management strategies, and prepare technical reports.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	Study research papers, technical reports, and case studies on smart water grids, urban water infrastructure, and digital water management.	24
2	Complete a MOOC/online course on urban water systems, IoT applications, smart cities, GIS, or water distribution network modelling.	24
3	Prepare a technical presentation or report on emerging technologies, challenges, and future trends in smart urban water management.	24

Sample rubrics for TW activities:

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
Problem	Clearly defines	Good	Basic	Problem definition is

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
Understanding	urban water system challenges and smart water grid objectives.	understanding with minor gaps.	understanding of urban water management concepts.	unclear.
Data and Method	Appropriate water demand, supply, distribution, and monitoring data used with correct methodology.	Suitable data and methods with minor errors.	Limited data or partially suitable methods.	Inadequate data and methods.
Analysis	Accurate analysis of water distribution networks, system performance, and smart grid applications.	Good analysis with minor errors.	Basic analysis with limited interpretation.	Poor or incomplete analysis.
Recommendations	Practical and sustainable solutions for urban water management and smart water grid implementation proposed.	Relevant recommendations with minor limitations.	General recommendations.	Weak or unsupported recommendations.
Presentation	Well-organized and professional presentation.	Clear presentation with minor issues.	Adequate presentation.	Poorly organized presentation.

SEDIMENT TRANSPORT & RIVER MORPHOLOGY			
Course Code	**1MCWR206B**	Scheme	2026
Type of Course	**Professional Elective Course**	Semester	II
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course outcome (Course Skill Set):

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

1. CO1: To provide a comprehensive understanding of sediment characteristics, transport, and entrainment processes in fluvial systems.
2. CO2: To explore the physical and chemical properties of sediments and their environmental significance.
3. CO3: To apply advanced sediment analysis techniques including laser particle analysis, X-ray diffractometry, and electron microscopy.
4. CO4: To develop skills in interpreting sediment data and modeling sediment flux and concentrations.
5. CO5: To connect sediment dynamics to river morpho dynamics and environmental chemistry.

Module-1

Fundamentals of Sediment and Fluvial Processes

- Types of fluvial sediments
- Sediment transport mechanisms (bed load, suspended load)
- Entrainment processes and initiation of motion
- Sediment movement in rivers

Linked COs: CO1 **Number of Hours: 8 hrs**

Module-2

Properties and Grain Size Analysis

- Grain size distribution, texture, shape, sorting, and packing
- Sediment density, porosity, and permeability
- Textural maturity and particle orientation

Linked COs: CO2 **Number of Hours: 9 hrs**

Module-3

Characterization and Analytical Techniques

- Mechanical analysis: grade scales and frequency distributions
- Laser Particle Analysis (LPA)
- X-ray Diffractometry (XRD)
- Atomic Absorption Spectrophotometry (AAS)
- Scanning Electron Microscopy (SEM)
- Graphical representation and shape analysis

Linked COs: CO3 **Number of Hours: 9 hrs**

Module-4

Transport Dynamics and Modelling

- Sediment transport equations and concepts
- Sediment flux and concentration dynamics
- Modelling of sediment transport in river systems

Linked COs: CO4 **Number of Hours: 8 hrs**

Module-5

Chemistry, Contaminant Transport and Environmental Aspects

- Environmental chemistry of sediments
- Nutrient and contaminant transport in sediments
- Adsorption and interaction of pollutants with sediments
- Impact of sediment transport on water quality and ecosystem

Linked COs: CO5 **Number of Hours: 8 hrs**

Suggested Learning Resources

Textbooks

1. V. A. Vanoni (Ed.), Sedimentation Engineering, Manuals and Reports on Engineering Practice No. 54, American Society of Civil Engineers (ASCE), New York, 1975.
2. C. T. Yang, Sediment Transport: Theory and Practice, McGraw-Hill Book Company, New York, 1996.
3. T. Kusuda, H. Yamanishi, J. Spearman and J. Z. Gailani (Eds.), Sediment and Ecohydraulics (INTERCOH 2005), Elsevier, Amsterdam, 2007.
4. R. J. Garde and K. G. Ranga Raju, Mechanics of Sediment Transportation and Alluvial Stream Problems, 3rd Edition, New Age International Publishers, New Delhi, 2000.
5. Ro Charlton, Fundamentals of Fluvial Geomorphology, Routledge, London, 2008.

Reference Books

1. Julien, P. Y., River Mechanics, 2nd Edition, Cambridge University Press, New York, 2010.
2. Garcia, M. H. (Ed.), Sedimentation Engineering: Processes, Measurements, Modeling and Practice, ASCE Manuals and Reports on Engineering Practice No. 110, American Society of Civil Engineers, Reston, Virginia, 2008.
3. Knighton, D., Fluvial Forms and Processes: A New Perspective, Arnold Publishers, London, 1998.
4. Chang, H. H., Fluvial Processes in River Engineering, Krieger Publishing Company, Florida, 1988.
5. Yang, C. T., Sediment Transport: Theory and Practice, Krieger Publishing Company, Florida, 1996.

Web links and Video Lectures (e-Resources)

1. https://nptel.ac.in
2. https://onlinecourses.nptel.ac.in
3. https://www.digimat.in/nptel
4. https://www.aapg.org/video
5. https://riverscapes.github.io/Fluvial-Geomorphology

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching

- Role Play

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**River basin and sediment characterization:** Analyze watershed characteristics, sediment sources, sediment properties, and river channel geometry.	24
2	**Sediment transport analysis:** Estimate sediment yield, bed load and suspended load transport using field data and analytical methods.	24
3	**River morphology assessment:** Study channel patterns, erosion and deposition processes, riverbank stability, and morphological changes using GIS and remote sensing tools.	24
4	**Modelling and report preparation:** Evaluate sediment transport behaviour, river training measures, and prepare technical reports based on case studies and simulations.	24

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	Study research papers, technical reports, and case studies on sediment transport processes, river dynamics, and channel evolution.	24
2	Complete a MOOC/online course on river engineering, fluvial hydraulics, sediment transport, GIS, or remote sensing applications.	24
3	Prepare a technical presentation or report on river restoration, sediment management practices, and sustainable river basin	24

	management.	

Sample rubrics for TW activities:

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
Problem Understanding	Clearly defines sediment transport and river morphology issues and objectives.	Good understanding with minor gaps.	Basic understanding of sediment transport concepts.	Problem definition is unclear.
Data and Method	Appropriate hydraulic, sediment, and river geometry data used with correct methodology.	Suitable data and methods with minor errors.	Limited data or partially suitable methods.	Inadequate data and methods.
Analysis	Accurate analysis of sediment movement, erosion, deposition, and channel morphology.	Good analysis with minor errors.	Basic analysis with limited interpretation.	Poor or incomplete analysis.
Recommendations	Practical river training, sediment management, and restoration measures proposed.	Relevant recommendations with minor limitations.	General recommendations.	Weak or unsupported recommendations.
Presentation	Well-organized and professional presentation.	Clear presentation with minor issues.	Adequate presentation.	Poorly organized presentation.

WATER RESOURCES OPTIMIZATION & DECISION SUPPORT SYSTEMS			
Course Code	**1MCWR206C**	Scheme	2026
Type of Course	**Professional Elective Course**	Semester	II
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course outcome (Course Skill Set):

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

1. CO1: To understand the water systems approach.
2. CO2: To apply problem formulation and optimization.
3. CO3: To apply reservoir operation and simulation models.
4. CO4: To apply the applications in emerging technologies.
5. CO5: Apply DSS, AI/ML, IoT, UAVs, and digital twin technologies for flood prediction, monitoring, and smart flood resilience planning.

Module-1

Introduction to Water Systems Approach

- Basic concepts of systems and systems engineering
- Need for systems approach in water resources
- Elements of water resources systems and system design principles

Linked COs: CO1 **Number of Hours: 8 hrs**

Module-2

Problem Formulation and Optimization

- Formulation of water resources problems
- Linear programming: graphical method, Simplex algorithm
- Dynamic Programming
- Sensitivity analysis and system reliability

Linked COs: CO2 **Number of Hours: 9 hrs**

Module-3

Reservoir Operation and Simulation Models

- Reservoir operation problems and capacity expansion planning
- Simulation techniques for water systems
- Multi-reservoir system analysis
- Case studies of reservoir system performance

Linked COs: CO3 **Number of Hours: 9 hrs**

Module-4

Applications with Emerging Technologies

- Use of GPS, GIS, RS and Decision Support Systems (DSS) in watershed management; technologies for rain-fed farming; socio-economic evaluation of the watershed management projects.

Linked COs: CO4 **Number of Hours: 8 hrs**

Module-5

Decision Support Systems and Emerging Technologies

- Real-time decision support systems (DSS) for water monitoring and emergency response
- AI and machine learning applications in prediction
- Internet of Things (IoT), UAVs, and community-sourced data for flood monitoring
- Digital twins and smart flood resilience infrastructure planning

Linked COs: CO5 **Number of Hours: 8 hrs**

Suggested Learning Resources

Textbooks

1. Loucks, D.P., Stedinger, J.R., Haith, D.A., Water Resources Systems Planning and Management, Prentice Hall, New Jersey, 1987
2. Hall, K.A., and Dracup, J.A., Water Resources Systems Engineering, Tata McGraw Hill, 1970
3. Grigg, N.S., Water Resources Planning, McGraw Hill, 1985
4. Ministry of Jal Shakti, Government of India, National Water Policy, New Delhi, 2012

Reference Books

1. Wurbs, R. A. and James, W. P., Water Resources Engineering, Prentice Hall, New Jersey, 2002.
2. Mays, L. W., Water Resources Engineering, 3rd Edition, John Wiley & Sons, New York, 2019.
3. Loucks, D. P. and van Beek, E., Water Resource Systems Planning and Management: An Introduction to Methods, Models and Applications, UNESCO Publishing, Paris, 2017.
4. Viessman, W. and Lewis, G. L., Introduction to Hydrology, 5th Edition, Pearson Education, New Delhi, 2008.
5. Chow, V. T., Maidment, D. R. and Mays, L. W., Applied Hydrology, McGraw-Hill Book Company, New York, 1988.

Web links and Video Lectures (e-Resources)

1. National Water Policy – Ministry of Jal Shakti, Government of India **https://jalshakti-dowr.gov.in**
2. Central Water Commission (CWC), Government of India **https://cwc.gov.in**
3. National Institute of Hydrology (NIH), Roorkee **https://nihroorkee.gov.in**
4. NPTEL – Water Resources Engineering **https://nptel.ac.in**
5. UNESCO – Water Resources Management and Governance https://www.unesco.org/en/water-security

Teaching-Learning Process (Innovative Delivery Methods):

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- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:
Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]
A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.
In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks

Students' activities for TW/SL under NCrF: Samples only
As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Water resources system analysis:** Study reservoir systems, irrigation networks, water allocation problems, and resource management objectives.	24
2	**Optimization model development:** Formulate and solve optimization problems using linear programming, dynamic programming, and multi-objective optimization techniques.	24
3	**Decision Support System (DSS) applications:** Develop and apply DSS tools for reservoir operation, water allocation, drought management, and policy evaluation.	24
4	**Scenario analysis and reporting:** Evaluate alternative management strategies, interpret results, and prepare technical reports and presentations.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	Study research papers, technical reports, and case studies on water resources optimization and decision support systems.	24
2	Complete a MOOC/online course on optimization techniques, operations research, systems engineering, or water resources management.	24
3	Prepare a technical presentation or report on the application of DSS and optimization methods for sustainable water resources planning and management.	24

Sample rubrics for TW activities:

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
Problem Understanding	Clearly defines water resources optimization problems and	Good understanding with minor gaps.	Basic understanding of optimization concepts.	Problem definition is unclear.

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
	decision-making objectives.			
Data and Method	Appropriate hydrologic, economic, and operational data used with correct optimization methodology.	Suitable data and methods with minor errors.	Limited data or partially suitable methods.	Inadequate data and methods.
Analysis	Accurate analysis of optimization results and decision support outcomes.	Good analysis with minor errors.	Basic analysis with limited interpretation.	Poor or incomplete analysis.
Recommendations	Practical and effective water resources management strategies proposed based on optimization results.	Relevant recommendations with minor limitations.	General recommendations.	Weak or unsupported recommendations.
Presentation	Well-organized and professional presentation.	Clear presentation with minor issues.	Adequate presentation.	Poorly organized presentation.

HYDRO INFORMATICS & AI FOR WATER MANAGEMENT			
Course Code	**1MCWR206D**	Scheme	2026
Type of Course	**Professional Elective Course**	Semester	I
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course outcome (Course Skill Set):

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

1. CO1: Understand the fundamentals of hydro informatics, hydrological modeling, and the role of AI/ML in water resources engineering.
2. CO2: Apply supervised learning techniques such as regression models and GLMs for prediction and analysis of hydrological data.
3. CO3: Analyze and implement classification methods including decision trees, SVM, ANN, and ensemble learning techniques for water system applications.
4. CO4: Apply unsupervised learning and multivariate analysis techniques such as clustering, PCA, and SVD for hydrological data interpretation
5. CO5: Evaluate and use hydro informatics tools for climate change assessment, flood frequency analysis, and smart water management systems.

Module-1

Introduction to Hydro informatics and Programming

- Introduction to hydro informatics and data-driven modeling for water systems
- Importance of hydro informatics in water resources engineering
- Model classification and overview of hydrological models
- Modeling accuracy, uncertainty, and performance evaluation
- Introduction to Artificial Intelligence (AI) and Machine Learning (ML)
- Introduction to MATLAB and R Programming for hydrological applications

Linked COs: CO1 **Number of Hours: 8 hrs**

Module-2

Supervised Learning – Regression Techniques

- Linear regression and multiple regression models
- Polynomial regression and generalized additive models
- Generalized Linear Models (GLMs): Logistic, Poisson, Gamma, and Exponential models
- Regularization methods and model selection
- Resampling methods: Bootstrap and cross-validation
- Machine Learning system design principles

Linked COs: CO2 **Number of Hours: 9 hrs**

Module-3

Supervised Learning – Classification and Advanced Methods

- k-Nearest Neighbors (kNN)
- Decision Trees: Classification and Regression Trees (CART)
- Ensemble methods: Bagging, Boosting, and Random Forests
- Support Vector Machines (SVM)
- Artificial Neural Networks (ANN)
- Kernel-based learning methods

Linked COs: CO3 **Number of Hours: 9 hrs**

Module-4

Unsupervised Learning and Multivariate Analysis

- Clustering techniques: Hard clustering (k-means)
- Fuzzy clustering (Fuzzy C-means) and introduction to fuzzy logic
- Dimension reduction techniques
- Singular Value Decomposition (SVD)
- Principal Component Analysis (PCA)
- Canonical Correlation Analysis (CCA)

Linked COs: CO4 **Number of Hours: 8 hrs**

Module-5

Applications of Hydro informatics

- Hydro informatics for climate change impact assessment
- Regional flood frequency analysis
- Hydrologic Information Systems (HIS)
- AI/ML applications in flood forecasting and drought prediction
- Smart water management systems and decision support tools
- Case studies in water resources management

Linked COs: CO5, CO6 **Number of Hours: 8 hrs**

Suggested Learning Resources

Textbooks

1. S. Rajasekaran and G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis and Applications. New Delhi, India: Prentice Hall of India (PHI), 2003.
2. J.-S. R. Jang, C.-T. Sun, and E. Mizutani, Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence. Upper Saddle River, NJ, USA: Prentice Hall, 1997.
3. K. Srinivasa Raju and D. Nagesh Kumar, Multicriteria Analysis in Engineering and Management. New Delhi, India: Prentice Hall of India (PHI), 2010.
4. M. A. Marino and J. E. B. Smith, Hydrology: An Integrated Approach. New York, NY, USA: McGraw-Hill, 1985.

Reference Books

1. S. N. Sivanandam and S. N. Deepa, Principles of Soft Computing, 3rd ed. New Delhi, India: Wiley India, 2018.
2. T. J. Ross, Fuzzy Logic with Engineering Applications, 4th ed. Chichester, U.K.: John Wiley & Sons, 2016.
3. D. E. Goldberg, Genetic Algorithms in Search, Optimization and Machine Learning. Reading, MA, USA: Addison-Wesley, 1989.
4. S. Haykin, Neural Networks and Learning Machines, 3rd ed. Upper Saddle River, NJ, USA: Pearson Education, 2009.
5. C. P. Padhy, Artificial Intelligence and Intelligent Systems. New Delhi, India: Oxford University Press, 2005.

Web links and Video Lectures (e-Resources)

1. NPTEL – Soft Computing- **https://nptel.ac.in**
2. NPTEL – Artificial Intelligence - **https://onlinecourses.nptel.ac.in**
3. MathWorks – Fuzzy Logic Toolbox - **https://www.mathworks.com/help/fuzzy**
4. MathWorks – Neural Networks and Deep Learning - **https://www.mathworks.com/solutions/deep-learning.html**
5. MATLAB YouTube Channel – Soft Computing Tutorials - https://www.youtube.com/@MATLAB

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Water data acquisition and management:** Collection, processing, visualization, and management of hydrological, meteorological, and water quality datasets using digital platforms and databases.	24
2	**Hydro informatics tools and modelling:** Application of GIS, remote sensing, IoT, and hydro informatics software for water resources assessment and monitoring.	24

3	**AI and machine learning applications:** Development of AI/ML models for rainfall-runoff prediction, flood forecasting, water demand estimation, drought assessment, and water quality prediction.	24
4	**Decision support and smart water management:** Integration of hydro informatics and AI tools for decision-making, scenario analysis, and preparation of technical reports and presentations.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	Study research papers, technical reports, and case studies on hydro informatics, artificial intelligence, digital water technologies, and smart water management systems.	24
2	Complete a MOOC/online course on Artificial Intelligence, Machine Learning, Python programming, GIS, Remote Sensing, or Hydro informatics applications in water resources engineering.	24
3	Prepare a technical presentation or report on AI-driven solutions for water resources planning, flood forecasting, drought management, and sustainable water governance.	24

Sample rubrics for TW activities:

Criteria	**4 - Excellent**	**3 - Good**	**2 - Satisfactory**	**1 - Needs Improvement**
Problem Understanding	Clearly defines water management challenges and AI-based solution objectives.	Good understanding with minor gaps.	Basic understanding of hydro informatics concepts.	Problem definition is unclear.
Data and Method	Appropriate hydrological data, computational tools, and AI techniques used with correct methodology.	Suitable data and methods with minor errors.	Limited data or partially suitable methods.	Inadequate data and methods.
Analysis	Accurate analysis of model outputs, predictions, and decision-support results.	Good analysis with minor errors.	Basic analysis with limited interpretation.	Poor or incomplete analysis.
Recommendations	Practical and effective AI-driven solutions for water resources management proposed.	Relevant recommendations with minor limitations.	General recommendations.	Weak or unsupported recommendations.

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
Presentation	Well-organized and professional presentation.	Clear presentation with minor issues.	Adequate presentation.	Poorly organized presentation.

WATER DISTRIBUTION NETWORK MODELLING WITH EPANET			
Course Code	**1MCWR206E**	Scheme	2026
Type of Course	**Professional Elective Course**	Semester	II
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course outcome (Course Skill Set):

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

1. CO1: Apply EPANET tools to develop and simulate basic water distribution network models.
2. CO2: Analyze hydraulic behavior of water distribution systems under steady-state and extended period simulations.
3. CO3: Evaluate the performance of water distribution systems using pumps, valves, head loss analysis, and demand patterns.
4. CO4: Apply water quality simulation, leak detection, and model calibration techniques for efficient network management.
5. CO5: Design and optimize real-world water distribution systems using EPANET through case studies and engineering projects.

Module-1

Introduction to EPANET and Network Development

Introduction to EPANET software, graphical user interface, toolbars, nodes, links, reservoirs, junctions, tanks and pipes; creation of simple water distribution networks; selection of units; assigning elevations, base demands and hydraulic properties; defining pipe length, diameter and roughness coefficients; execution of basic hydraulic simulations and interpretation of simulation results.

Linked COs: CO1 **Number of Hours: 8 hrs**

Module-2

Hydraulic Analysis of Water Distribution Networks

Development and analysis of branched and looped water distribution networks; assignment of hydraulic parameters; steady-state hydraulic simulations; pressure and flow analysis; head loss calculations; effect of pipe diameter, roughness coefficient and elevation on hydraulic performance; comparison of hydraulic characteristics under varying operating conditions.

Linked COs: CO2 **Number of Hours: 9 hrs**

Module-3

Extended Period Simulation and Network Components

Extended Period Simulation (EPS); demand pattern development; simulation duration and time-step settings; temporal variation of pressure, flow and storage; modelling pumps and pump characteristic curves; pressure reducing valves (PRV), flow control valves (FCV), control rules, operational scenarios and system performance evaluation.

Linked COs: CO3 **Number of Hours: 9 hrs**

Module-4

Water Quality Modelling and Model Calibration

Introduction to water quality modelling in EPANET; constituent transport analysis; conservative tracer studies; reaction coefficients; leakage modelling; closed pipe analysis; alternate flow path identification; identification of critical links; comparison of simulated and observed field data; calibration of network models through adjustment of demand and roughness parameters; model validation.

Linked COs: CO4 **Number of Hours: 8 hrs**

Module-5

Water Distribution System Design and Optimization

Development of real and hypothetical water distribution network models; demand and supply assessment; optimization of pipe sizing and network layout; evaluation of system performance under varying demand conditions; reliability assessment; engineering case studies; preparation and presentation of mini projects using EPANET for sustainable water distribution system planning and management.

Linked COs: CO5 **Number of Hours: 8 hrs**

Suggested Learning Resources

Textbooks:

1. Santiago Arnalich, *Epanet and Development: How to Calculate Water Networks by Computer*, Arnalich Publications, 2011.
2. Santiago Arnalich, *Epanet and Development: A Progressive 44 Exercise Workbook*, Arnalich Publications, 2011.
3. N. Trifunovic, *Introduction to Urban Water Distribution*, CRC Press, 2006.
4. Carlos A. Bonilla et al., *Introduction to Hydraulic Modeling: EPANET, SWMM, HEC-RAS*, Universidad de Pamplona, 2023.
5. R.K. Rai and Prashant Lingayat, *Analysis of Water Distribution Network Using EPANET*, SSRN, 2019.

Reference books:

1. J. D. Salas, W. W. Delleur, V. Yevjevich, and W. L. Lane, Applied Modeling of Hydrologic Time Series. Littleton, CO, USA: Water Resources Publications, 1980.
2. C. T. Haan, Statistical Methods in Hydrology. Ames, IA, USA: Iowa State University Press, 1977.
3. G. E. P. Box and G. M. Jenkins, Time Series Analysis: Forecasting and Control. San Francisco, CA, USA: Holden-Day, 1976.
4. R. T. Clarke, Mathematical Models in Hydrology. Rome, Italy: Food and Agriculture Organization (FAO), FAO Irrigation and Drainage Paper No. 19, 1973.
5. V. Yevjevich, Stochastic Processes in Hydrology. Fort Collins, CO, USA: Water Resources Publications, 1972.

Software Tools:

1. EPANET 2 User Manual**,** U.S. Environmental Protection Agency (EPA) – Primary reference for software usage, modelling procedures, and simulation details.
2. EPANET Programmer's Toolkit Documentation – Useful for advanced modelling and integration with other tools.

Web links and Video Lectures (e-Resources):

1. https://epanet22.readthedocs.io
2. https://epanet22.readthedocs.io/en/latest/2_quickstart.html
3. https://epanet22.readthedocs.io/en/latest/3_network_model.html

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may

include (but are not limited to):

- Flipped Classroom
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- Role Play

Assessment Structure (both CIE and SEE)

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In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks

Students' activities for TW/SL under NCrF: Samples only

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Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Water distribution network data preparation and model development:** Collection and organization of network data including junction elevations, pipe characteristics, reservoirs, tanks, pumps, valves, and demand data; development of water distribution network models using EPANET.	**24**
2	**Hydraulic analysis and network simulation:** Steady-state and extended period simulation (EPS) of water distribution systems; analysis of pressure, flow, velocity, head loss, storage variation, and system performance under varying demand conditions using EPANET.	**24**
3	**Network performance assessment and optimization:** Simulation of pump and valve operations, leakage scenarios, pipe closures, water quality analysis, model calibration, and optimization of pipe sizing and network performance for efficient water supply management.	**24**
4	**Case study and technical reporting:** Development of a real or hypothetical water distribution system model; evaluation of alternative design scenarios; preparation of engineering drawings, simulation outputs, technical reports, and presentation of findings using EPANET.	**24**
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	Study research papers, technical manuals, design standards (CPHEEO, AWWA, BIS), and case studies on water distribution systems, hydraulic network analysis, pressure management, leakage control, and EPANET-based modelling applications.	24
2	Complete a MOOC/online course or tutorial on EPANET, water distribution system modelling, hydraulic analysis, water quality simulation, or related GIS applications (ArcGIS/QGIS) for water supply engineering.	24
3	Prepare a technical report or presentation by developing an EPANET model of a real or hypothetical water distribution network, including hydraulic and water quality analysis, system optimization, and recommendations for sustainable water supply management.	24

Sample rubrics for TW activities:

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
Problem Definition and Network Development	Clearly defines the water distribution problem and develops a complete, accurate EPANET network model with appropriate assumptions.	Defines the problem well with minor omissions in the network model.	Basic network model developed with limited understanding of the problem.	Problem definition and network model are incomplete or inaccurate.
Model Setup and Hydraulic Simulation	Correctly assigns all hydraulic parameters (demands, elevations, pipes, pumps, valves, tanks) and successfully performs simulations with accurate results.	Appropriate model setup with minor errors that do not significantly affect results.	Model setup is partially correct with noticeable errors in parameters or simulations.	Incorrect model setup leading to unreliable or incomplete simulation results.
Analysis and Interpretation	Thoroughly analyzes pressure, flow, velocity, head loss, water quality, and system performance; accurately interprets simulation results and identifies critical issues.	Good analysis with minor errors in interpretation.	Basic analysis with limited interpretation of simulation outputs.	Poor or incomplete analysis with incorrect interpretation of results.
Optimization	Proposes practical	Relevant	General	Recommendations

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
and Engineering Recommendations	and technically sound improvements for network performance, pressure management, leakage reduction, or pipe sizing based on simulation results.	recommendations with minor limitations.	recommendations with limited technical justification.	are weak, unsupported, or absent.
Technical Report and Presentation	Well-structured technical report with clear figures, EPANET outputs, tables, and professional presentation of results.	Clear report and presentation with minor formatting or presentation issues.	Adequate report with limited organization or clarity.	Poorly organized report and presentation with incomplete documentation.

HYDROLOGY & HYDRAULIC MODELLING LAB			
Course Code	1MCWRL207	Scheme	2026
Type of course	Professional Core Course Lab	Semester	II
Teaching Hours/Week (L:T:P)	2(0: 0: 2)	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	30(0: 0:28:2)	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	**Practical**	Exam Hours	3

Course outcome (Course Skill Set)

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

1. CO1: Determine average rainfall for given catchment
2. CO2: Analyze rainfall runoff relationship.
3. CO3: Determine water quality, parameters, hydrologic properties
4. CO4: Analyze sediment load, simulation problems of hydrology.
5. CO5: Determine water surface profiles, boundary layer and Velocity distribution profile for different types of flow in open channels.

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 10 conventional experiments, PART-B has 4 typical open-ended experiments. The maximum marks for the laboratory course are 100.
2. Both PART-A and PART-B are considered for CIE and SEE.
3. Students have answers 1(one) question from PART-A and 1(one) question from PART-B.
    a. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for 70 marks out of the maximum 100 marks.
    b. The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for 30 marks.
4. 4. For continuous internal evaluation, during the semester, classwork, the typical open-ended questions shall be from PART-B, and any other similar questions to enhance the skill of the students.

PART – A

FIXED EXPERIMENTS

1. Measurement of rainfall, evaporation, infiltration, laboratory and field tests.
2. Determination of average rainfall over a catchment.
3. Rainfall – Runoff Studies
4. Determination of Water Quality and Wastewater Parameters
5. Determination of In-situ soil Hydrological Properties
6. Measurement of sediment load; Water balance studies
7. Determination of Infiltration Characteristics
8. Determination of Hydraulic Conductivity with Constant Head Permeameter
9. Computer programs and software applications for hydrologic analysis and simulation problems.
10. Measurement of velocity profile in straight and meandering open channel;
11. Experiments on velocity distribution and Boundary shear in rough and smooth channels,
12. Discharge measurement by weir to find critical depth and Surface profile;
13. Characteristics of Hydraulic Jump in horizontal and Sloping Channels
14. Determination of Manning's N for Composite Sections
15. Velocity Distribution in Open Channels and momentum correction Factors
16. Drag coefficients of flow past cylinders
17. Boundary layer velocity profile.
18. Energy loss in Bends
19. Analysis of Distribution Networks

PART – B

OPEN ENDED EXPERIMENTS

1. Hydrological Modelling using open source software like HEC-HMS, HEC-GeoHMS.
2. Hydrodynamic modelling of River systems using open source softwarelike HEC-RAS, HEC-GeoRASetc.
3. Hydrodynamic modelling of River systems using licensed software like Mike family software.

Theoretical background of snow-melt runoff modelling including practical using open source software like WINSRM.

1. Determine areal rainfall for a given catchment using various averaging methods and interpret spatial rainfall distribution. **(CO1, CO3)**
2. Analyze rainfall–runoff relationships using hydrological data and evaluate watershed response under different rainfall conditions. **(CO2, CO4)**
3. Assess water quality parameters and hydrologic properties through laboratory testing and data interpretation. **(CO3, CO4)**
4. Develop simulation-based hydrological models to estimate sediment load and analyze watershed processes under varying conditions. **(CO2, CO4, CO5)**
5. Determine water surface profiles, boundary layer characteristics, and velocity distribution for different open channel flow conditions using hydraulic models. **(CO5, CO3)**

Textbooks:

1. J. R. M. Hosking and J. R. Wallis, Regional Frequency Analysis: An Approach Based on L-Moments. Cambridge, U.K.: Cambridge University Press, 2005.
2. D. R. Maidment, Ed., Handbook of Hydrology. New York, NY, USA: McGraw-Hill, 1993.
3. Central Water Commission, Manual on Flood Forecasting. New Delhi, India: Central Water Commission, 1989.
4. P. J. Reddy, Stochastic Hydrology. New Delhi, India: Laxmi Publications, 1987.
5. N. T. Kottegoda, Stochastic Water Resources Technology. Chichester, U.K.: John Wiley & Sons, 1980.

Reference books:

1. J. D. Salas, W. W. Delleur, V. Yevjevich, and W. L. Lane, Applied Modeling of Hydrologic Time Series. Littleton, CO, USA: Water Resources Publications, 1980.
2. C. T. Haan, Statistical Methods in Hydrology. Ames, IA, USA: Iowa State University Press, 1977.
3. G. E. P. Box and G. M. Jenkins, Time Series Analysis: Forecasting and Control. San Francisco, CA, USA: Holden-Day, 1976.
4. R. T. Clarke, Mathematical Models in Hydrology. Rome, Italy: Food and Agriculture Organization (FAO), FAO Irrigation and Drainage Paper No. 19, 1973.
5. V. Yevjevich, Stochastic Processes in Hydrology. Fort Collins, CO, USA: Water Resources Publications, 1972.

Web links and Video Lectures (e-Resources):

1. NPTEL courses
2. Software tutorial resources for project planning, scheduling, and visualization.

Software Tools:

- Commercial software: STAAD.Pro, ETABS, SAP2000, ANSYS Mechanical, MIDAS Civil, Autodesk Robot Structural Analysis, Tekla Structural Designer.
- Open-source software: OpenSees, FreeCAD, Code_Aster, Elmer FEM, CalculiX, SfePy, FRAME3DD.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation (CIE):

For the Professional Core Course Laboratory, the maximum marks prescribed are 100. Out of these, 50 marks are allotted for Continuous Internal Evaluation (CIE) and 100 marks for the Semester End Examination (SEE). The SEE marks obtained out of 100 shall be proportionately scaled down to 50 marks. The final result shall be declared based on the aggregate of the CIE marks (50) and the scaled-down SEE marks (50), totalling 100 marks."

Out of 50 marks, 40 marks shall be assigned for assessment of regular laboratory PART -A classwork, and 10 marks for Part – B. (Table 1)

Out of 40 marks, 25 marks shall be based on the regular classwork and allotment of marks shall be as per rubrics listed in Table 1.

The remaining 15 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for the practical test as indicated in the Table 1.

The open-ended question set for CIE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for 10 marks. The allotment of marks shall be as per rubrics listed in Table 2.

Table – 1 Distribution of marks corresponding to laboratory component

Component	Description	Marks
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	10 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	15 marks
	Subtotal	**25**
Allotment of marks for CIE practical test		
Laboratory Test / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	5 marks
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	10marks
	Subtotal	**15**
	Total	**40**

Table 2 Distribution of marks corresponding to PART -B of the laboratory component

Evaluation Rubrics for continuous internal evaluation CIE). Maximum marks:10

Criteria and Guiding factors	Students' Level and Rubrics
	Excellent: E, Good: G, Fair: F

	Needs Improvements: NI			
	E	**G**	**F**	**NI**
(1) Problem Understanding **Criteria:** Is the problem understood correctly and framed appropriately? (i)Clarity in interpreting the given problem. (ii)Identification of relevant concepts and constraints. (iii) Ability to rephrase or model the problem logically.	2.0	1.5	1.0	0.5
(2) Conceptual Knowledge **Criteria**: Are the chosen methods or concepts valid for this type of problem? (i)Application of appropriate theories, principles, or laws. (ii)Integration of multiple concepts where necessary. (iii)Accuracy in stating relevant equations or models.	2.0	1.5	1.0	0.5
(3) Approach and Strategy **Criteria**: Is the approach well thought out and methodical? (i)Logical structure and progression. (ii)Use of diagrams, sketches, or flowcharts if applicable. (iii)Identification of assumptions and boundary conditions.	2.0	1.5	1.0	0.5
(4) Execution and Accuracy **Criteria**: Are the calculations correct? Is the final solution reasonable? (i) Correct application of formulas/methods. (ii)Accuracy of calculations or simulations (if any). (iii)Unit consistency and result verification.	2.0	1.5	1.0	0.5
(5) Innovation or Depth **Criteria**: Has the student shown original thinking or alternative methods? (i)Novel or efficient solutions. (ii)Consideration of alternate approaches. (iii)Interdisciplinary integration or practical extensions.	1	0.75	0.5	0.25
(6) Presentation and Clarity **Criteria**: Is the answer easy to follow and professionally written? (i)Organization and neatness. (ii)Clarity of explanation, labelling, and steps. (iii) Use of proper technical terminology.	1	0.75	0.5	0.25
Total	10	7.5	5.0	2.5

Note:
(i)The marks shown for Excellent, Good, Fair, Needs Improvement are indicative. The evaluator may also assign intermediate scores depending on the quality of work.
(ii)If the total score results in a fraction, it should be rounded off to the next higher integer.
(iii)The listed criteria are guidelines; evaluators may also consider other authentic dimensions (e.g., depth of insight, critical thinking, and practical awareness, recognition of limitations, or justified compromises.
(iv)To award the full10 marks in the excellent category, the student must demonstrate reasonably good performance across all six criteria; otherwise, proportionally lower marks may be given.

MINOR PROJECT/SKILL DEVELOPMENT			
Course Code	**1MCWR208**	Scheme	2026
Type of Course	**Professional Core Course**	Semester	II
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	2	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course outcome (Course Skill Set):

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

1. CO1: Demonstrate a sound technical knowledge of their selected project topic.
2. CO2: Undertake problem identification, formulation, and solution
3. CO3: Design engineering solutions to complex problems utilizing a systems approach.
4. CO4: Communicate with engineers and the community at large in written an oral form.

Project Phase

Project Phase – I: Students in consultation with the guide/s shall carry out literature survey/ visit industries to finalize the topic of the Project. Subsequently, the students shall collect the material required for the selected project, prepare synopsis and narrate the methodology to carry out the project work.

Seminar: Each student, under the guidance of a Faculty, is required to

- Present the seminar on the selected project orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit two copies of the typed report with a list of references.

The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.

Project Work Phase - II: Each student of the project batch shall involve in carrying out the project work jointly in constant consultation with internal guide, co-guide, and external guide and prepare the project report as per the norms avoiding plagiarism.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity.

The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.		
Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1	**Problem identification and literature survey:** Select a relevant engineering problem and conduct a literature review to understand existing solutions.	24
2	**Project planning and design:** Define objectives, methodology, work plan, and expected outcomes of the project.	24
3	**Development and implementation:** Carry out experiments, simulations, model development, prototype preparation, or field investigations.	24
4	**Analysis and documentation:** Analyze results, prepare technical reports, and present project findings.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	Study research papers, case studies, or technical reports related to the selected project topic and prepare a summary.	24
2	Complete a MOOC/Spoken Tutorial course relevant to project development, data analysis, programming, or emerging technologies.	24
3	Develop a presentation, poster, or technical portfolio showcasing project outcomes and acquired skills.	24

Sample rubrics for TW activities:

Criteria	**4 - Excellent**	**3 - Good**	**2 - Satisfactory**	**1 - Needs Improvement**
Problem Understanding	Clearly defines the problem and objectives.	Good understanding with minor gaps.	Basic understanding of the problem.	Problem definition is unclear.
Planning and Execution	Well-planned and effectively executed.	Good planning with minor issues.	Adequate planning and execution.	Poor planning and execution.
Technical Skills/Application	Demonstrates excellent technical skills and application.	Good technical competency.	Basic technical competency.	Limited technical skills demonstrated.
Innovation and Creativity	Highly innovative and creative approach.	Some innovative ideas incorporated.	Limited innovation shown.	No significant innovation demonstrated.
Presentation	Well-organized and professional	Clear presentation with minor issues.	Adequate presentation.	Poorly organized presentation.

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
	presentation.			