DELHI TECHNOLOGICAL UNIVERSITY

Department of Civil Engineering

Syllabi for Master of Technology

Hydraulics and Water Resources Engineering

M. Tech. Hydraulics and Water Resources Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
HWE501: Advanced Fluid Mechanics	**L**	**T**	**P**	Nil
	3	0	2	

Course Objective: Introduction to concepts of fluid mechanics from both a theoretical and applications perspective for the students. The students will have sufficient mathematical and physical background to formulate real-life problems in fluid mechanics.

S. No	Course Outcomes (CO)
CO1	Formulate momentum, energy, and mass transport models.
CO2	Analyse Potential Flows.
CO3	Develop approximate solutions for small and large Reynolds number flows.
CO4	Apply laminar flow models.
CO5	Understand and analyse boundary layer formation and stresses acting at the boundary.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Kinematics of Flow: Equation of continuity in Cartesian, polar, and cylindrical coordinates, Standard 2D Flow Patterns: Source, sink, doublet, and their combinations, construction of flows by superposition, D'Alembert's paradox.	8
UNIT 2	Modelling and dimensional analysis: Introduction, Dimensional Homogeneity Methods of Dimensional analysis, Model Analysis, like types of similarity, Types of forces acting on moving fluids, Dimensionless numbers, Classification of models, and Model laws.	8
UNIT 3	Laminar Flow: Derivation of Navier-Stokes equations – exact solutions for flow between parallel plates, Couette flow, flow near a suddenly accelerated plate, and an oscillating plate.	8

UNIT 4	Boundary Layers: introduction, types of boundary layer, drag force on a flat plate due to boundary layer analysis of turbulent boundary layer, separation in boundary layer under adverse pressure gradient, and methods of preventing the separation of boundary layer.	8
UNIT 5	Fundamentals of compressible flows: Introduction, Thermodynamics Relations. Basic equations of compressible flow, velocity of sound or pressure wave in a fluid, and Mach number.	10
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	White, F.M., "Fluid Mechanics", McGraw-Hill.	1979
2	Schlichting, H., "Boundary Layer Theory", McGraw-Hill	1979
3	Advanced Engineering Fluid Mechanics Hardcover – K. Muralidhar (Author), G. Biswas, Alpha Science International Ltd (ISBN 0-07-748559-7)	2005

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.
PO2: An ability to write and present a substantial technical report/ document.
PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program.

M. Tech. Hydraulics and Water Resources Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
HWE502: Advanced Open Channel Hydraulics	**L**	**T**	**P**	Nil
	3	0	2	

Course Objective: The objective of this course is to provide students with an in-depth understanding of advanced concepts and analytical techniques in open channel hydraulics. The course aims to equip students with the skills necessary to analyse, design, and manage complex open channel flow systems through a combination of theoretical knowledge and practical application.

S. No	Course Outcomes (CO)
CO1	Advanced Flow Analysis
CO2	Design and Optimization
CO3	Hydraulic Structures
CO4	Integrated Water Resources Management
CO5	Computational Modelling

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Kinds of open channel flow, channel geometry, types and regimes of flow, Velocity distribution in open channel, wide open channel, specific energy, critical flow, and its computation.	8
UNIT 2	Energy in a non-prismatic channel, momentum in open channel flow, and specific force. Qualification of uniform flow, velocity measurement, Manning's and Chezy's formula, determination of roughness coefficients.	8
UNIT 3	Determination of normal depth and velocity, most economical sections, and non-erodible channels. Flow in a channel section with composite roughness, and flow in a closed conduit with open channel flow.	8

UNIT 4	Varied Flow: Dynamic equations of gradually varied flow, assumptions and characteristics of flow profiles, classification of flow profile, draw down and back water curves profile determination, graphical integration, direct step and standard step method, numerical methods, flow through transitions Varied Flow: Dynamic equation of spatially varied flow. Analysis of spatially varied flow profile, computation of spatially varied flow using numerical integration.	10
UNIT 5	Unsteady Flows: St. Venant's equations and their solution using the method of characteristics and finite difference schemes; dam break problem, hydraulic flood routing. Channel Transitions: Sub-critical and supercritical.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Chow, V.T., "Open Channel Hydraulics", McGraw-Hill.	1959
2	Choudhary, M.H., "Open-Channel Flows", Prentice-Hall	1994
3	Ranga Raju, K.G., "Flow Through Open Channels, Tata McGraw Hill	2003

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/ document.

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M. Tech. Hydraulics and Water Resources Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
HWE503: Advanced Hydrology	**L**	**T**	**P**	Nil
	3	0	2	

Course Objective: The objective of this course is to provide an in-depth understanding of the complex processes governing the distribution, movement, and quality of water on Earth. By integrating theoretical concepts with practical applications, students will develop the skills necessary to analyse and solve advanced hydrological problems. The course will cover topics such as surface and groundwater hydrology, hydrological modelling, climate change impacts on hydrological cycles, and water resource management. Upon completion, students will be equipped to conduct independent research, apply advanced hydrological techniques, and contribute effectively to water resource planning and management.

S. No	Course Outcomes (CO)
CO1	Understand and Analyse Hydrological Processes.
CO2	Apply Hydrological Models.
CO3	Evaluate Climate Change Impacts.
CO4	Conduct Independent Research.
CO5	Implement Water Resource Management Strategies.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Introduction: Hydrologic system and hydrologic budget, fundamental laws of hydrology; atmospheric water vapour. Hydrologic Inputs: Precipitation and its forms, snowfall and rainfall; measurement techniques and space-time characteristics.	10
UNIT 2	Hydrologic Abstractions: Infiltration, depression storage, evapotranspiration; measurement techniques, space-time characteristics, and their modelling	8

UNIT 3	Stream flow: Measurement techniques, space-time characteristics, rating curves	8
UNIT 4	System Approach: Unit Hydrograph IUH, GIUH. Mathematical Modelling: Linear and Nonlinear models, Physically based models.	8
UNIT 5	Hydrological routing, Flood forecasting. Advanced Method of Frequency Analysis: Outliers, Time series analysis. Impact of climate change and Land use/Land cover on basin response.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Chow, V.T., Maidment, D.R. and Mays, W.L., "Applied Hydrology", McGraw-Hill.	1988
2	Ojha, C.S.P., Berndtsson, R. and Bhunya, P., “Engineering Hydrology”, Oxford University Press.	2008
3	Wanielista, M., Kersten, R. and Eaglin, R., “Hydrology”, John Wiley.	1997

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.

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M. Tech. Hydraulics and Water Resources Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
	L	**T**	**P**	
HWE504: Design of Hydraulic Structures	3	0	2	Nil

Course Objective: The objective of this course is to provide students with the comprehensive knowledge and skills necessary for the design, analysis, and evaluation of hydraulic structures. The course focuses on the principles, methodologies, and practical aspects of designing various hydraulic structures such as dams, spillways, weirs, and culverts, with an emphasis on safety, efficiency, and sustainability.

S. No	Course Outcomes (CO)
CO1	Understanding of the fundamental principles and concepts involved in the design and functioning of various hydraulic structures, including the forces acting on these structures and the methods to analyse them.
CO2	Ability to design hydraulic structures such as dams, spillways, weirs, and culverts.
CO3	Safety assessments and risk analyses for hydraulic structures, understanding the potential hazards, failure modes, and designing structures to mitigate these risks effectively.
CO4	Proficient in using computational tools and software.
CO5	Enhance their project management skills, including planning, executing, and presenting design projects.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Project planning of hydraulic structure, site investigation, selection of hydraulic structures (w.r.t foundation), and Different types of dams.	10
UNIT 2	Design and Construction of Gravity Dams.	8
UNIT 3	Design and Construction of Earthen Dams and Rockfill Dams.	8

UNIT 4	Design & analysis of weirs and barrages.	8
UNIT 5	Design and Analysis of different types of spillways and energy dissipaters.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Garg, S.K. Irrigation engineering and hydraulic structures. Khanna Publishers.	1987
2	Varshney, R. S., Gupta, S. C., & Gupta, R. L. Theory & Design of Irrigation Structures: Nem Chand & Bros.	1979
3	Novák, P., Moffat, A. I. B., Nalluri, C., & Narayanan, R. " Hydraulic structures." CRC Press.	2001

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.
PO2: An ability to write and present a substantial technical report/ document.
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M. Tech. Hydraulics and Water Resources Engineering

Course code: Course Title	Course Structure.			Pre-Requisite
	L	T	P	
HWE505: Water Power Engineering	3	0	2	Nil

Course Objective: The objective of this course is to provide students with a thorough understanding of the principles and applications of water power engineering, focusing on the design, analysis, and management of hydraulic systems for energy production. The course will cover the fundamentals of hydropower generation, including the engineering and environmental aspects of dam construction, turbine technology, and the integration of hydropower into the electrical grid. Students will also explore sustainable practices and innovations in water power engineering to address global energy needs. By the end of the course, students will be equipped with the technical knowledge and practical skills necessary to design, evaluate, and optimize water power systems for efficient and sustainable energy production.

S. No	Course Outcomes (CO)
CO1	Understand Hydropower Fundamentals
CO2	Design Hydropower Systems
CO3	Evaluate Environmental and Social Impacts
CO4	Optimize Hydropower Operations
CO5	Implement Innovative Solutions

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Introduction: Development of water power, Estimation of Hydropower potential, Comparison of Hydro, thermal and nuclear power, Flow duration curve, firm power, secondary power, Load and Load duration curves, Load	8

	factor, etc.	
UNIT 2	Types of Hydropower Plants: Classification of hydropower plants, Run-of-river plants, Valley dam plants, High head diversion plants, Diversion Canal plants, pumped storage plants, and Tidal power plants.	8
UNIT 3	Water Conveyance System: Power canals, Alignment, Design of power canals, Flumes, Covered conduits and tunnels, Drainage and ventilation in tunnels. Penstocks: - Alignment, types of penstocks, economic diameter of penstocks, and Anchor blocks. Fore bay, Intakes, Balancing Reservoir, Escape, Surge Shafts/ Inclined Shafts. General Layout of power house and arrangement of hydropower units. Underground Power Stations.	10
UNIT 4	Dams: Selection of site, preliminary investigations, Final investigations, Types of dams: - Rigid dams, Gravity dams, Arch and buttress dams, Basic principles of design and details of construction. Earthen dams, rock fill dams, and Design considerations. Spillways: Types, spillway gates, Design of stilling basins.	8
UNIT 5	Types of Turbines and their utility: Hydraulic Turbines, Classification Based on Head, Discharge, Turbines, Differences between Impulse and Reaction Turbines, choice of Type of Turbine-Specific Speed. Component Parts & Working Principles of a Pelton Turbine and Francis Turbine.	8
	TOTAL	**42**

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint
1	Loucks, D.P., Stedinger, J.R., and Haith, D.A., Water Resources Systems Planning and Analysis, 1st Ed., Prentice Hall.	1981
2	ReVelle, C.S., Whitlatch Jr, E.E., and Wright, J.R., Civil and Environmental Systems Engineering, Pearson Prentice Hall.	2004
3	James, L.D., and Lee, R.R., Economics of Water Resources Planning, McGraw-Hill.	1971
4	Smith, A. A., Hinton, E., and Lewis, R.W., Civil Engineering Systems Analysis and Design, John Wiley and Sons.	1983

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

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PO2: An ability to write and present a substantial technical report/ document.
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M. Tech. Hydraulics and Water Resources Engineering

Course code: Course Title	Course Structure.			Pre-Requisite
	L	T	P	
HWE507: Computational Hydraulics	3	0	2	Nil

Course Objective: The objective of this course is to equip students with the theoretical knowledge and practical skills necessary to analyse and solve complex hydraulic problems using computational methods. The course will cover the fundamentals of fluid dynamics, numerical modelling techniques, and the application of computational tools to simulate water flow in natural and engineered systems. Students will learn to develop and validate models, interpret simulation results, and apply these techniques to real-world scenarios such as flood prediction, river and coastal engineering, and water resource management. By the end of the course, students will be proficient in using computational hydraulics to support engineering decision-making and research in water-related fields.

S. No	Course Outcomes (CO)
CO1	Apply Numerical Modeling Techniques
CO2	Develop and Validate Computational Models
CO3	Analyze and Interpret Simulation Results
CO4	Solve Complex Hydraulic Problems
CO5	Integrate Computational Tools in Water Resource Management

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Introduction to Computational Fluid Dynamics and Principles of Conservation: Continuity Equation, Navier-Stokes Equation, Energy Equation, and General Structure of Conservation Equations, Classification of Partial Differential Equations and Physical Behaviour. Approximate Solutions of Differential Equations: Error Minimization Principles, Variational Principles and Weighted	8

	Residual Approach.	
UNIT 2	Fundamentals of Discretization: Finite Element Method, Finite Difference and Finite Volume Method, Finite Volume Method: Some Conceptual Basics and Illustrations through 1-D Steady State Diffusion Problems, Boundary Condition Implementation and Discretization of Unsteady State Problems, Important Consequences of Discretization of Time Dependent Diffusion Type Problems.	8
UNIT 3	Stability Analysis: Consistency, Stability and Convergence, LAX Equivalence theorem, Grid independent and time independent study, Stability analysis of parabolic equations (1-D unsteady state diffusion problems): FTCS (Forward time central space) scheme, Stability analysis of parabolic equations (1-D unsteady state diffusion problems): CTCS scheme (Leap frog scheme), Dufort-Frankel scheme, Stability analysis of hyperbolic equations: FTCS, FTFS, FTBS and CTCS Schemes.	8
UNIT 4	Finite Volume Discretization of 2-D Unsteady State Diffusion Type Problems, Solution of Systems of Linear Algebraic Equations: Elimination Methods, Iterative Methods, Gradient Search Methods.	8
UNIT 5	Discretization of Convection-Diffusion Equations: A Finite Volume Approach, Discretization of Navier Stokes Equations: Stream Function Vorticity approach and Primitive variable approach, SIMPLE Algorithm, SIMPLER Algorithm, Unstructured Grid Formulation, Introduction to Turbulence Modelling.	10
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Anderson, "Computational Fluid Mechanics and Heat Transfer", McGraw-Hill.	1984
2	Chung, T. J., "Finite Element Analysis in Fluid Dynamics", McGraw-Hill.	1978
3	Anderson, & Weessner, "Applied Groundwater Modelling", Academic Press.	1992
4	Chaudhary, H. M., "Applied Hydraulic Transient", McGraw-Hill.	1976

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/ document.

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M. Tech. Hydraulics and Water Resources Engineering

Course code: Course Title	Course Structure.			Pre-Requisite
	L	T	P	
HWE511: Sediment Transport	3	1	0	Nil

Course Objective: The objective of this course is to provide students with a comprehensive understanding of the principles and dynamics of sediment transport in natural and engineered environments. The course will cover the fundamental concepts of sediment mechanics, sediment-water interactions, and the processes governing erosion, transport, deposition, and consolidation of sediments.

S. No	Course Outcomes (CO)
CO1	Understand Sediment Transport Processes
CO2	Apply Analytical and Computational Methods
CO3	Assess Environmental and Engineering Implications
CO4	Design Sediment Management Strategies
CO5	Conduct Independent Research

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Introduction of sediment transport, sediment problems, properties of sediments, and incipient motion of uniform and non-uniform sediments.	8
UNIT 2	Bed forms and channel resistance. Bed load and suspended load transport for uniform and non-uniform bed material, total load equations, and sediment sampling.	8
UNIT 3	Stable channel design and sediment control.	8

UNIT 4	Bed level variations, local scour, degradation, aggradation, and reservoir sedimentation. Physical and mathematical models.	10
UNIT 5	Design of guide bunds and other river training banks.	8
	TOTAL	**42**

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint
1	Garde, R.J., “River Morphology”, New International Publishers.	2006
2	Julien, P.Y., “Erosion and Sedimentation”, Cambridge University Press.	1998
3	Jansen, P.P.H., “Principles of River Engineering”, VSSD Publications.	1994
4	Garde, R.J. and Ranga Raju, K.G., "Mechanics of Sediment Transportation and Alluvial Stream Problems", Wiley Eastern Limited.	2006

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.
PO2: An ability to write and present a substantial technical report/ document.
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M. Tech. Hydraulics and Water Resources Engineering

Course code: Course Title	Course Structure.			Pre-Requisite
	L	**T**	**P**	
HWE513: Irrigation and Drainage Engineering	3	1	0	Nil

Course Objective: The objective of this course is to provide students with a comprehensive understanding of the principles, design, and management of irrigation and drainage systems. The course will cover the theoretical foundations and practical applications of irrigation and drainage engineering, including water requirements for various crops, soil-water-plant relationships, design and operation of irrigation systems, and drainage methods for agricultural lands.

S. No	Course Outcomes (CO)
CO1	Understand Soil-Water-Plant Relationships
CO2	Design Efficient Irrigation Systems
CO3	Develop and Implement Drainage Solutions
CO4	Develop and Implement Drainage Solutions
CO5	Conduct Independent Research and Projects

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Water Resources of India - Irrigation- Need, Advantages and Disadvantages, History of Irrigation development in India- National Water Policy- Inadequacy of Irrigation Management- Criteria for good Irrigation management. Introduction: Water resources planning process, multi-objective planning.	10
UNIT 2	Soil physical properties influencing Soil-water Relationship-Forms and occurrence of Soil Water Classification of Soil Water- Soil Water Constants-Energy concept of Soil Water-Forces acting on Soil Water- Soil Water Potential concept- Soil Water retention- Soil Moisture Measurement.	8

UNIT 3	Water requirement of crops- Evapotranspiration and Consumptive use- Methods of estimating Evapotranspiration- Effective Rainfall- Irrigation Requirement-Duty of Water- Irrigation Efficiencies Irrigation Scheduling- Irrigation measurement.	8
UNIT 4	Canal network and canal design- Surface irrigation methods- Types- Border irrigation, Furrow irrigation and Strip irrigation- Specifications, Hydraulics and Design.	8
UNIT 5	Problems of water logging- salinity and alkalinity, land drainage problem-design of surface and sub-surface drainage system, reclamation. Water Quality Management Models: Basic water quality modelling,	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Walker, W.R., and Skogerboe, G.V., "Surface Irrigation Theory and Practice", Prentice Hall, INC.	1987
2	Drainage Principles and Applications, "International Institute for Land Reclamation and Improvement", Wageningen.	1973
3	Michael, A.M., "Irrigation: Theory and Practice", Vikas Publishing House.	1978
4	Asawa, G.L., "Irrigation Engineering", New Age International Publishers.	1996

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.
PO2: An ability to write and present a substantial technical report/ document.
PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program.

M. Tech. Hydraulics and Water Resources Engineering

Course code: Course Title	Course Structure.			Pre-Requisite
HWE520: Groundwater Hydrology	**L**	**T**	**P**	Nil
	3	1	0	

Course Objective: The objective of this course is to provide students with a comprehensive understanding of the principles and practices of groundwater hydrology. The course aims to equip students with the skills necessary to analyse, model, and manage groundwater systems, addressing issues related to groundwater flow, contamination, and sustainable use.

S. No	Course Outcomes (CO)
CO1	Develop a thorough understanding of the physical principles governing groundwater flow, including aquifer properties, Darcy's law, and the groundwater flow equations.
CO2	Proficiency in constructing and utilizing groundwater flow models using tools such as MODFLOW, enabling them to simulate and analyze groundwater flow under various conditions.
CO3	learn to model contaminant transport in groundwater, understanding the processes of advection, dispersion, and chemical reactions, and develop strategies for groundwater contamination remediation.
CO4	ability to design and implement sustainable groundwater management practices
CO5	Enhance their research skills by investigating contemporary issues in groundwater hydrology

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Introduction: Definition of groundwater, role of groundwater in the hydrological cycle, groundwater bearing formations, classification of aquifers, flow and storage characteristics of aquifers, Darcy's law, anisotropy, and heterogeneity.	8
UNIT 2	Wells and Well Hydraulics: Different types of wells, construction of wells, steady and unsteady state solutions for confined, unconfined, and leaky aquifers, effect of boundaries, Multiple Well Systems, Partially Penetrating	8

	Wells, Well for special Conditions, Characteristics of Well Losses, Specific Capacity.	
UNIT 3	Surface investigation of groundwater: Geologic methods, Remote sensing, geophysical exploration, Electric resistivity Method, Seismic Refraction Method, Gravity and Magnetic Methods, Water Witching.	8
UNIT 4	Concept of Artificial Recharge of Groundwater, recharge methods, research on water spreading, Wastewater recharge for reuse, Recharge Mounds. Artificial Recharge on Long Island, New York, includes recharge, artificial Recharge for Energy purposes.	10
UNIT 5	Groundwater Flow Modelling: Porous media models, Analog models, Electric Analog Models, and Digital computer models.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Todd, D.K., "Groundwater Hydrology", John Wiley.	1959
2	Bear, J., "Hydraulics of Groundwater", McGraw-Hill.	1979
3	Bouwer, H., "Groundwater Hydrology", McGraw-Hill.	1978
4	Walton, W.C., "Groundwater Resources Evaluation", McGraw-Hill.	1970

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.
PO2: An ability to write and present a substantial technical report/ document.
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M. Tech. Hydraulics and Water Resources Engineering

Course code: Course Title	Course Structure.			Pre-Requisite
HWE522: Design of Flood Control and River Training Works	**L**	**T**	**P**	Nil
	3	1	0	

Course Objective: The objective of this course is to provide students with the knowledge and skills necessary to design, analyse, and implement effective flood control and river training measures. The course emphasizes understanding the dynamics of river systems, assessing flood risks, and applying engineering principles to mitigate flood hazards and manage riverine environments sustainably.

S. No	Course Outcomes (CO)
CO1	Gain a comprehensive understanding of the physical processes governing river dynamics, including sediment transport, channel morphology, and river hydraulics.
CO2	Develop the ability to assess flood risks using hydrological and hydraulic modeling tools.
CO3	Design various flood control structures.
CO4	Proficiency in designing and implementing river training works, including groynes, revetments, etc.
CO5	Enhance their ability to develop integrated flood management plans that combine structural and non-structural measures.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Basic causes of floods: Flood-prone areas in India and their problems, case history of some important river basins of India. Engineering and administrative methods of floodplain regulation. Economic aspects of flood control schemes, cost-benefit analysis.	10
UNIT 2	Flood forecasting, flood warning, and flood fighting. Morphological study of river behaviour.	8
UNIT 3	Theories of river meandering and river regimes. Necessity, principles and methods of river training.	8

UNIT 4	Case history of river training works in India and abroad.	8
UNIT 5	Design of Levees, Groynes, Cut-offs, and Guide Bunds, etc. River training works for different hydraulic structures.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Garde, R.J., "River Morphology", New International Publishers.	2006
2	Julien, P.Y., "Erosion and Sedimentation", Cambridge University Press.	1998
3	Jansen, P.P.H., "Principles of River Engineering", VSSD Publications.	1994
4	Garde, R.J. and Ranga Raju, K.G., "Mechanics of Sediment Transportation and Alluvial Stream Problems", Wiley Eastern Limited.	2006

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.
PO2: An ability to write and present a substantial technical report/ document.
PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program.

M. Tech. Hydraulics and Water Resources Engineering

Course code: Course Title	Course Structure.			Pre-Requisite
	L	T	P	
HWE530: Hydro-informatics and Simulation	3	1	0	Nil

Course Objective: The objective of this course is to provide students with a comprehensive understanding of hydro-informatics principles and simulation techniques used in water resources engineering. The course aims to equip students with the skills to apply advanced computational methods, data analysis, and modelling tools to solve complex water-related problems and enhance decision-making processes.

S. No	Course Outcomes (CO)
CO1	Develop the ability to use advanced hydro-informatics tools and software.
CO2	Expertise in handling and analyzing large datasets related to hydrology and water resources.
CO3	Develop, calibrate, and validate hydrological and hydraulic models to ensure their accuracy and reliability in predicting water system behaviors under various scenarios.
CO4	Acquire the skills to integrate multiple models and datasets to create comprehensive decision support systems.
CO5	Enhance their research skills by exploring contemporary challenges and innovations in hydro-informatics.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Introduction, Concept of hydro-informatics, scope of the internet and web-based modelling in water resources engineering. Introduction to multi-criterion decision support system – Components for modelling software.	8
UNIT 2	Introduction to Simulation, Different simulation techniques – Applications of simulation techniques in hydraulics.	8
UNIT 3	Introduction to Artificial Neural Networks, Networks and their Training- Back propagation algorithm.	8

UNIT 4	Conjugate gradient algorithm, Cascade correlation algorithm, Applications of ANN in Water Resources Engineering.	8
UNIT 5	Genetic Algorithm (G.A.) Concept, Basic principle of GA, Working principle of GA. Coding, Fitness function, GA. Operations, Reproduction, Crossover Mutation, Applications of GA in Water Resources Engineering.	10
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Kumar, P., Hydro informatics: Data Integrative Approaches in Computation, Analysis, and Modeling, CRC Press.	2005
2	Grayson, R. and G. Blöschl, Spatial Patterns in Catchment Hydrology: Observations and Modelling, Cambridge University Press, Cambridge.	2000
3	Tomer, S.K., Python in Hydrology, Grean Tea Press, Indian Institute of Science.	2012

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/ document.

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program.

M. Tech. Hydraulics and Water Resources Engineering

Course code: Course Title	Course Structure.			Pre-Requisite
HWE532: Ground Improvement Techniques	**L**	**T**	**P**	Nil
	3	**1**	**0**	

Course Objective: The objective of this course is to provide students with a thorough understanding of the principles, methods, and applications of ground improvement techniques used in geotechnical engineering. The course aims to equip students with the knowledge and skills necessary to design and implement effective ground improvement solutions to enhance soil properties and ensure the stability and performance of civil engineering structures.

S. No	Course Outcomes (CO)
CO1	Gain a comprehensive understanding of soil behavior, properties, and the necessity for ground improvement in various geotechnical engineering applications.
CO2	Acquire detailed knowledge of various ground improvement techniques.
CO3	Develop the ability to design and implement appropriate ground improvement techniques.
CO4	Learn to evaluate the performance of ground improvement techniques through field testing, monitoring, and instrumentation.
CO5	Enhance their ability to identify and apply sustainable and innovative ground improvement solutions.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Introduction: situations where ground improvement becomes necessary. Mechanical modification: dynamic compaction, impact loading, compaction by blasting, vibro-compaction; pre-compression, stone columns.	8
UNIT 2	Hydraulic modification: dewatering systems, preloading and vertical drains, electro-kinetic dewatering. Chemical modification, modification by admixtures, stabilization using industrial wastes, and grouting.	8

UNIT 3	Thermal modification: ground freezing and thawing.	8
UNIT 4	Soil reinforcement: Reinforced earth, basic mechanism, type of reinforcements, selection of stabilisation/improvement of ground using Geotextiles, Geogrid, geomembranes, geocells, geonets, and soil nails.	8
UNIT 5	. Application of soil reinforcement: shallow foundations on reinforced earth, design of reinforced earth retaining walls, reinforced earth embankment structures, walls with reinforced backfill, analysis and design of shallow foundations on reinforced earth, road designs with geosynthetics.	10
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Hausmann, M.R., Engineering Principles of Ground Modification, McGraw-Hill International Editions.	1990
2	Yonekura, R., Terashi, M. and Shibazaki, M. (Eds.), Grouting and Deep Mixing, A.A. Balkema.	1966
3	Moseley, M.P., Ground Improvement, Blackie Academic & Professional.	1993
4	Xanthakos, P.P., Abramson, L.W. and Bruce, D.A., Ground Control and Improvement, John Wiley & Sons.	1994

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.
PO2: An ability to write and present a substantial technical report/ document.
PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program.

M. Tech. Hydraulics and Water Resources Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
HWE540: Computational Lab-HWE	**L**	**T**	**P**	**Nil**
	0	0	8	

Course Objective: Familiarize students with computational tools and basic concepts in hydraulics.

S. No	**Course Outcomes (CO)**
CO1	Proficiency in Hydraulics and Hydrologic Software.
CO2	Application of Theoretical Concepts.
CO3	Simulation and Analysis Skills.
CO4	Integrated Water Resources Management.
CO5	Problem-Solving and Project Management.

CO-PO Articulation Metrices

Course Outcome	**PO1**	**PO2**	**PO3**
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	**Contents**	**Contact hours**
UNIT 1	Introduction to Computational Tools, Overview of software: MATLAB, HEC-RAS, SWAT, Flow-3D. Installation and basic setup, Simple calculations and scripts in MATLAB.	5
UNIT 2	Introduction to HEC-RAS interface, Creating and editing river geometries, Simulating steady flow in HEC-RAS, Unsteady flow simulation, Hydraulic structures: bridges, culverts, weirs, Floodplain mapping and analysis.	8
UNIT 3	Introduction to the SWAT interface, building a watershed model in SWAT, Simulating rainfall-runoff processes, modelling urban drainage systems, land use/land cover, and Analysing model results.	8
UNIT 4	Introduction to MODFLOW interface, building a groundwater flow model, simulating steady-state and transient conditions, Basics of contaminant transport in groundwater, Advection, dispersion, and chemical reactions, using	8

	MT3DMS with MODFLOW for transport simulations.	
UNIT 5	Introduction to Flow-3D, geometry formation, model setup, and result analysis. Different model analyses include spillways, weirs, sediment transport in open channels, and flow in non-prismatic channels.	8
UNIT 6	Introduction to Computational Tools, Overview of software: MATLAB, HEC-RAS, SWAT, Flow-3D. Installation and basic setup, simple calculations and scripts in MATLAB.	5
	TOTAL	**42**
REFERENCES		
S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Software manuals and online resources for MATLAB, HEC-RAS, SWAT, FLOW-3D, and MODFLOW.	Prevailing versions

M. Tech. Hydraulics and Water Resources Engineering					
Course code: Course Title		**Course Structure.**			**Pre-Requisite**
HWE541: Introduction to AI Techniques		**L**	**T**	**P**	**Nil**
		1	0	2	

Course Objective: The objective of this course is to introduce students to fundamental techniques and concepts in Artificial Intelligence (AI). The course will cover the basic principles of AI, machine learning, and deep learning, as well as their applications in various domains. Students will learn about different AI techniques, algorithms, and methodologies used for problem-solving and decision-making tasks. The course aims to provide a solid foundation in AI, enabling students to understand the capabilities and limitations of AI technologies and apply them effectively in practical scenarios. By the end of the course, students will be prepared to explore advanced topics in AI and pursue further studies or careers in AI-related fields.

S. No	**Course Outcomes (CO)**
CO1	Understand Fundamental AI Concepts.
CO2	Apply AI Techniques.
CO3	Evaluate AI Models.
CO4	Utilize AI Tools and Frameworks.
CO5	Discuss Ethical and Social Implications

CO-PO Articulation Metrices

Course Outcome	**PO1**	**PO2**	**PO3**
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	**Contents**	**Contact hours**
UNIT 1	Expert Systems (ES): Basic concepts of ES, definition, and components of ES. Reasoning mechanisms, e.g., forward reasoning and backward reasoning.	5
UNIT 2	Concept of causable variable, knowledge representation methods, and development of the rule-based knowledge base, dealing with uncertainty, linear and nonlinear behaviour of variables, statistical concepts, and their applications	4

	to engineering and sciences.	
UNIT 3	Artificial Neural Networks (ANNs): background and history of ANNs, definitions and basic concepts of ANNs, biological and artificial neural networks, feed-forward and feed-back networks.	4
UNIT 4	Supervised and unsupervised learning methods–standard back-propagation (BP), concept of learning, learning rate and momentum concepts, self-organizing networks, etc., development of ANN models for specific problems, and selected case studies.	4
UNIT 5	Introduction to Genetic Algorithms (GAs): fundamentals and preliminary concepts of evolution and GA, preliminaries of optimization, genetic operators-selection, crossover, and mutation, binary and real-coded GAs, selected case studies involving GA applications to engineering.	5
	TOTAL	**22**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Russell & Norvig: Artificial Intelligence; A Modern Approach, 3rd edition.	2010
2	Qiangfu ZHAO and Tatsuo Higuchi, Artificial Intelligence: from fundamentals to intelligent searches, Kyoritsu.	2017

M. Tech. Hydraulics and Water Resources Engineering					
Course code: Course Title		**Course Structure.**			**Pre-Requisite**
HWE542: Modeling and Simulation in HWE		**L**	**T**	**P**	**Nil**
		2	0	4	

Course Objective: Familiarising students with basic concepts of related computational tools in the field of hydraulics, and state-of-the-art practice of applications of computational tools in Hydraulics and Water Resources Engineering.

S. No	Course Outcomes (CO)
CO1	Proficiency in Hydraulics and Hydrologic Software.
CO2	Application of theoretical concepts and computational tools in the field of fluid mechanics/ hydraulics.
CO3	Simulation and Analysis Skills for Hydraulics and Water Resources Engineering.
CO4	Integrated Water Resources Management.
CO5	Problem-Solving and Project Management for Hydraulics and Water Resources Engineering.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Introduction to Computational Tools, Overview of software: MATLAB, HEC-RAS, SWAT, Flow-3D. Installation and basic setup, Simple calculations and scripts in MATLAB.	5
UNIT 2	Introduction to HEC-RAS interface, Creating and editing river geometries, Simulating steady flow in HEC-RAS, Unsteady flow simulation, Hydraulic structures: bridges, culverts, weirs, Floodplain mapping and analysis.	8
UNIT 3	Introduction to the SWAT interface, building a watershed model in SWAT, Simulating rainfall-runoff processes, modelling urban drainage systems, land use/land cover, and Analysing model results.	8

UNIT 4	Introduction to MODFLOW interface, building a groundwater flow model, simulating steady-state and transient conditions, Basics of contaminant transport in groundwater, Advection, dispersion, and chemical reactions, using MT3DMS with MODFLOW for transport simulations.	8
UNIT 5	Introduction to Flow-3D, geometry formation, model setup, and result analysis. Different model analyses include spillways, weirs, sediment transport in open channels, and flow in non-prismatic channels.	8
UNIT 6	Introduction to Computational Tools, Overview of software: MATLAB, HEC-RAS, SWAT, Flow-3D. Installation and basic setup, simple calculations and scripts in MATLAB.	5
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Software manuals and online resources for MATLAB, HEC-RAS, SWAT, FLOW-3D, and MODFLOW.	Prevailing versions

M. Tech. Hydraulics and Water Resources				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
HWE601: Water Resources Systems Planning and Management	**L**	**T**	**P**	Nil
	3	0	2	

Course Objective: The objective of the course is to provide students with the knowledge and skills needed to design, plan, and manage water resource systems effectively. The course focuses on understanding water resources' hydrological, economic, and environmental aspects, integrating sustainability and resilience principles. Students will learn to apply quantitative and qualitative methods for decision-making, optimize water resource allocation, and address challenges such as climate change, water scarcity, and stakeholder conflicts. Through case studies and practical projects, students will develop the ability to create and implement comprehensive water management strategies.

S. No	Course Outcomes (CO)
CO1	Apply hydrological and systems analysis techniques to water resource planning.
CO2	Develop and optimize sustainable water management strategies.
CO3	Analyse economic, environmental, and social impacts of water resource decisions.
CO4	Utilize decision-making tools for effective water allocation and conflict resolution.
CO5	Address challenges in water management, including climate change and resource scarcity.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Introduction: Water resources planning process, multi-objective planning. Evaluation of Water Plans: Basic concepts of engineering economics, welfare economics, and economic comparison of alternatives.	8
UNIT 2	Water Plan Optimization: Plan formulation, objective functions and constraints, analytical optimization, numerical optimization, linear programming, dynamic programming, simulation, planning under uncertainty.	8

UNIT 3	Deterministic River Basin Modelling: Stream flow modelling, estimation of reservoir storage requirements – dead storage, active storage for water supply/irrigation/power generation, flood storage. Optimal allocation.	10
UNIT 4	Conjunctive Use/Groundwater Management Models: LP-based conjunctive use modelling, aquifer response models, link-simulation, embedded, matrix response-based models, soft modelling.	8
UNIT 5	Water Quality Management Models: Basic water quality modelling, objectives of management, control alternatives, optimal plans.	8
	TOTAL	**42**

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REFERENCES		
S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Hall, W.A. and Dracup, J.A., "Water Resources Systems Engineering", McGraw-Hill Book Company.	1970
2	Loucks, D.P., "Water Resource Systems Planning and Analysis", Prentice Hall.	1981
3	Maass et al., "Design of Water-Resource Systems", Harvard University Press.	1962
4	Vedula S. and Mujumdar, P.P., "Water Resources Systems", Tata McGraw-Hill.	2005