SYLLABUS

OF

M. TECH

(Hydraulics and Water Resources Engineering)

I YEAR

(CBCS)

DEPARTMENT OF CIVIL ENGINEERING

INTEGRAL UNIVERSITY LUCKNOW

STUDY AND EVALUATION SCHEME

M.Tech. (Hydraulics and Water Resources Engineering)

(w.e.f. Batch 2021-22)

Semester – I

S. No.	Course Category	Code No	Name of Subject	Periods			Credits	Evaluation Scheme				Subject Total
				L	T	P	C	Continuous Assessment (CA)			Exam ESE	
								UE	TA	Total		
1	DC	CE566	Open Channel Hydraulics	3	1	-	4	40	20	60	40	100
2	DC	CE556	Water Resources Systems Planning and Management	3	1	-	4	40	20	60	40	100
3	DC	CE557	Advanced Hydraulic Engineering	3	1	-	4	40	20	60	40	100
4	DE		Elective - I	3	1	-	4	40	20	60	40	100
5	DC	CE563	Experimental Method in Water Resources Engineering	-	-	3	2	-	-	60	40	100
Total							**18**					**500**

Semester – II

S. No.	Course Category	Code No	Name of Subject	Periods			Credits	Evaluation Scheme				Subject Total
				L	T	P	C	Continuous Assessment (CA)			EXAM ESE	
								UE	TA	Total		
1	DC	CE565	Applied Hydrology	3	1	-	4	40	20	60	40	100
2	DC	CE552	Research Methodology	3	1	-	4	40	20	60	40	100
3	DC	CE568	Climate Change Impacts in Water Resources Engineering	3	1	-	4	40	20	60	40	100
4	DC	CE572	Research Paper Presentation and Discussion/Seminar	-	-	-	4	-	-	60	40	100
5	DC	CE567	Computer Methods in Hydraulics and Hydrology	-	-	3	2	-	-	60	40	100
Total							**18**					**500**

TA- Teacher Assessment; **ESE –** End Semester Examination; **CT-** Cumulative Test.

Note: Duration of ESE shall be 03 (Three) hours per subject

STUDY AND EVALUATION SCHEME (Evening)

M.Tech. (Hydraulics and Water Resources Engineering)

(w.e.f. Batch 2021-22)

Semester – I

S. No.	Course Category	Code No	Name of Subject	PERIODS			Credits	EVALUATION SCHEME				Subject Total
				L	T	P	C	Continuous Assessment (CA)			EXAM ESE	
								UE	TA	Total		
1	DC	CEE566	Open Channel Hydraulics	3	1	-	4	40	20	60	40	100
2	DC	CEE557	Advanced Hydraulic Engineering	3	1	-	4	40	20	60	40	100
3	DC	CEE563	Experimental Method in Water Resources Engineering	-	-	3	2	-	-	60	40	100
Total							**10**					**300**

Semester – II

S. No.	Course Category	Code No	Name of Subject	PERIODS			Credits	EVALUATION SCHEME				Subject Total
				L	T	P	C	Continuous Assessment (CA)			EXAM ESE	
								UE	TA	Total		
1	DC	CEE565	Applied Hydrology	3	1	-	4	40	20	60	40	100
2	DC	CEE552	Research Methodology	3	1	-	4	40	20	60	40	100
3	DC	CEE567	Computer Methods in Hydraulics and Hydrology	-	-	3	2	-	-	60	40	100
Total							**10**					**300**

UE- Unit Exam, **TA-** Teacher Assessment; **ESE –** End Semester Examination.

Note: Duration of ESE shall be 03 (Three) hours per subject

M.Tech (Hydraulics and Water Resources Engineering)

List of the Elective Paper:

Elective – I

CE555/CEE555	Mathematics and Statistics for Hydraulic Engineering
CE558/CEE558	Modeling Simulation and Optimization
CE560/CEE560	Advanced Numerical Analysis
CE561/CEE561	Flood and Drought

Elective – II

CE660/CEE660	Remote Sensing and GIS in Water Resources Engineering
CE661/CEE661	Hydro Power Engineering
CE662/CEE662	Advanced Irrigation Engineering

Elective – III

CE664/CEE664	Fluvial Hydraulics
CE665/CEE665	Application of Soft Computing Technique in Hydrology
CE666/CEE666	River Engineering

Elective – IV

CE668/CEE668	Hydraulic Structures
CE669/CEE669	Watershed Management
CE670/CEE670	Earth and rock fill Dams

TA- Teacher Assessment; ESE- End Semester Examination; CT- Cumulative Test

Note: Duration of ESE shall be 03 (Three) hours per subject.

CE555/CEE555	MATHEMATICS AND STATISTICS FOR HYDRAULIC ENGINEERING				
Pre-requisite	**Co-Requisite**	**L**	**T**	**P**	**C**
	NIL	3	1	0	4
Objective	To develop the necessary mathematical aptitude as relevant to hydraulic engineers.				
Unit-I	**Calculus**				**08 Hrs.**
Multiple integration, spherical coordinate systems, ordinary differential equations, partial differential equations, polar coordinates, conformal mapping.					
Unit-II	**Linear Algebra**				**08 Hrs.**
Eigen values and eigen vectors, singular value decomposition, orthogonal decomposition, crouts and do littel algorithm, solution of linear equations.					
Unit-III	**Probability and Statistics**				**08 Hrs.**
Distributions, CDF and PDF, measures of central tendency, application to hydraulic engineering, Fractals.					
Unit-IV	**Fourier Transform and Integrals**				**08 Hrs.**
Fourier and integral transform, Fourier sine series, cosine series, application to decomposition problems.					
Unit-V	**Mathematical Modelling**				**08 Hrs.**
Numerical methods, Eulers method, Newton's Raphsons method, Gauss Siedel method, Gauss elimination method.					

References:

1. Shanti Narayan: A Text Book of Martices, S. Chand & Co.
2. Thomas/Finny: Calculus and Analytical Geometry, Narosa Pub.
3. B.S. Grewal: Higher Engineering Mathematics, Khanna Publishers.
4. Piskunov, M. Differential and Integral Calculus, Moscow Peace Pub.
5. Jaggi and Mathur: Advanced Engineering Mathematics, Khanna Pub.
6. C. Prasad: Mathematics for Engineers, Prasad Pub.

Web links to e-learning:

1. https://nptel.ac.in/courses/105105105/
2. https://nptel.ac.in/downloads/105105104/

CE556/CEE556	WATER RESOURCES SYSTEMS PLANNING AND MANAGEMENT				
Pre-requisite	**Co-Requisite**	**L**	**T**	**P**	**C**
	NIL	3	1	0	4
Objective	To develop suitable plans for water resource development and management, estimation of sustainable yield of water resources, assess surface and ground water resources and principles of integrated water resources management.				
Unit-I	**Introduction**				**08 Hrs.**
General Principles of Systems Analysis to Problems in Water Resources Engineering, Objectives of Water Resources Planning and Development, Nature of Water Resources Systems, Socio Economic Characteristics.					
Unit-II	**Economic Analysis of Water Resources System**				**08 Hrs.**
Principles of Engineering Economy, Capital, Interest and Interest Rates. Time Value of Money, Depreciation, Benefit Cost Evaluation, Discounting Techniques, Economic and Financial Evaluation, Socio-Economic Analysis.					
Unit-III	**Methods of Systems Analysis**				**08 Hrs.**
Linear Programming Models, Simplex Method, Sensitivity Analysis, Dual Programming, Dynamic Programming Models, Classical Optimization Techniques, Gradient Techniques, Stochastic Programming, Simulation, Search Techniques, Multi Objective Optimization.					
Unit-IV	**Water Quantity Management**				**08 Hrs.**
Surface Water Storage Requirements, Storage Capacity and Yield, , Water Allocations for Water Supply, Hydropower and Flood Control, Reservoir Operations, Irrigation , Planning of an Irrigation System, Irrigation Scheduling.					
Unit-V	**Design of Systems**				**08 Hrs.**
Groundwater management, Conjunctive Use of Surface and Subsurface Water Resources, Reservoir Design, Design of Water Conveyance and Distribution Systems.					

References:

1. Chaturvedi, M.C. “Water Resources Systems Planning and Management”, Tata McGraw Hill Pub. Co., N Delhi.
2. Hall. W.A. and Dracup, J.A. “Water Resources Systems”, Tata McGraw Hill Pub. N Delhi.
3. James, L.D. and Lee “Economics of Water Resources Planning”, McGraw Hill Inc. N York.
4. Kuiper, E. “Water Resources Development, Planning, Engineering and Economics”, Buttersworth, London.
5. Biswas, A.K. “Systems Approach to Water Management”, McGraw Hill Inc. N York.

Web links to e-learning:

1. https://nptel.ac.in/courses/105/108/105108081/

CE557/CEE557	ADVANCED HYDRAULIC ENGINEERING				
Pre-requisite	**Co-Requisite**	**L**	**T**	**P**	**C**
	NIL	3	1	0	4
Objective	To understand the hydraulic engineering principle in various problems of practical world.				
Unit-I	**Fundamentals of Fluid Flow**				**08 Hrs.**
Fluid properties, Forces on immersed bodies, buoyancy, meta centre, flow measurement, shear and normal forces, lift and drag force.					
Unit-II	**Free Surface Flows**				**08 Hrs.**
Free surface equation, governing principles, flow over the hump, width contraction, elevation and transition, GVF profiles, hydraulic jump.					
Unit-III	**Dimensional Analysis**				**08 Hrs.**
Dimensional analysis and similitude, Buckingham pi theorem, similarity laws, laminar and turbulent flows, navier stokes equation, Bernaulli's and eulers equation.					
Unit-IV	**Finite Element Method**				**08 Hrs.**
Finite element method theory, derivation, application to potential flow problems, source sink, application to transient problems, shape functions.					
Unit-V	**Potential Flow Theory**				**08 Hrs.**
Stream function, velocity potential, Gama and beta function, application to seepage problems, flow dynamics, Darcy's law. Ground water flow.					

References:

1. A.K..Jain "*Fluid Mechanics* ", Nem Chand & Bros.; 7th Edition 2012
2. Modi and seth , "*Fluid Mechanics",* McGraw Hill Education; 3rd Edition 2009
3. F.M.White "*Fluid Mechanics ",* Mc-Graw Hill Publications,1st Edition Reprint 2007

Web links to e-learning:

1. https://nptel.ac.in/courses/105105105/
2. https://nptel.ac.in/downloads/105105104/

CE558/CEE558	MODELING SIMULATION AND OPTIMIZATION				
Pre-requisite	**Co-Requisite**	**L**	**T**	**P**	**C**
	NIL	3	1	0	4
Objective	To understand the Concepts of systems and systems analysis, Linear programming, Dynamic programming, Simulation Multi-objective planning and optimization of hydropower systems.				
UNIT I	**Introduction and Optimization**				**08 Hrs.**
Introduction: Definition and types of system, optimization: functions of a single variable, functions of a multiple variables, constrained optimization.					
UNIT II	**Linear Programming**				**08 Hrs.**
Introduction to linear programming: graphics method, simplex method, multiple solutions, unbounded and infeasible problems, dual problem.					
UNIT III	**Dynamic Programming**				**08 Hrs.**
Introduction to dynamic programming: water allocation problem, reservoir operation problem, capacity and expansion and shortest route problem.					
UNIT IV	**Simulation, Objective Planning and Fuzzy Optimization**				**08 Hrs.**
Simulation: introduction to multi – objective planning, Multi objective planning, Fuzzy optimization for water quality control and reservoir operation.					
UNIT V	**Model formulations and Case Studies**				**08 Hrs.**
Conjunctive use of ground and surface water, hydropower optimization, crop yield optimization, multi-basin and multi – reservoir system.					

References:

1. Loucks, D.P. and Eelco van Beek (2005). Water resources systems planning and management: An introduction to methods, models and applications. UNESCO.
2. Vedula, S. and Mujumdar, P.P. (2005). Water resources systems: Modeling techniques and analysis, Tata McGraw Hill, New Delhi.
3. Mays, L.W. and Tung, Y.K. (1992). Hydrosystems engineering and management, McGraw Hill, USA.
4. Simonovic, S.P. (2009). Managing water resources: Methods and tools for a systems approach, UNESCO publishing, France.

Web links to e-learning:

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

CE560/CEE560	ADVANCED NUMERICAL ANALYSIS				
Pre-requisite	**Co-Requisite**	**L**	**T**	**P**	**C**
	NIL	3	1	0	4
Objective	To enable the students to Know and understand Numerical Methods, Distinguish between Numerical differences, integration and classical difference & Integration and Apply the knowledge Extensively in Engineering and Statistics.				
Unit-I	**Curve Fitting**				**08 Hrs.**
Least – Squares curve fitting procedures, fitting a straight line, nonlinear curve fitting, Curve fitting by a sum of exponentials.					
Unit-II	**Numerical Differentiation**				**08 Hrs.**
Derivatives using Newton's forward difference formula, Newton's backward difference formula, Derivatives using central difference formula, Stirling's interpolation formula, Newton's divided difference formula, Maximum and minimum values of a tabulated function.					
Unit-III	**Numerical Integration**				**08 Hrs.**
General Quadrature formula on errors, Trapozoidal rule, Simpson's 1/3 – rule, Simpson's 3/8 – rule, and Weddle's rules, Euler – Maclaurin Formula of summation and quadrature, The Euler transformation.					
Unit-IV	**Solutions of simultaneous Linear Systems of Equations**				**08 Hrs.**
Solution of linear systems – Direct methods, Matrix inversion method, Gaussian elimination methods, Gauss-Jordan Method ,Method of factorization, Solution of Tridiagonal Systems,. Iterative methods. Jacobi's method, Gauss-siedal method.					
Unit-V	**Numerical Solution of Ordinary Differential Equations**				**08 Hrs.**
Introduction, Solution by Taylor's Series, Picard's method of successive approximations, Euler's method, Modified Euler's method, Runge – Kutta methods.					

References:

1. Numerical Analysis by S.S.Sastry, published by Prentice Hall India (Latest Edition).(2015)
2. Numerical Analysis by G. Sankar Rao, published by New Age International Publishers, New – Hyderabad.(2006)
3. Finite Differences and Numerical Analysis by H.C Saxena published by S. Chand and Company, Pvt. Ltd., New Delhi.(2009)
4. Numerical methods for scientific and engineering computation by M.K.Jain, S.R.K.Iyengar, R.K. Jain.(2002)

Web links to e-learning:

1. https://nptel.ac.in/courses/103/101/103101111/#

CE561/CEE561	FLOOD AND DROUGHT				
Pre-requisite	**Co-Requisite**	**L**	**T**	**P**	**C**
	NIL	3	1	0	4
Objective	To know the basic methods of flood estimation, Design flood, Probable maximum flood, Effects of drought on water resources and management of flood and drought.				
Unit-I	**Introduction**				**08 Hrs.**
Flood: Introduction, types, factor affecting flood, **Runoff:** Introduction, factors affecting runoff, estimation of runoff. **Hydrograph:** Flood Hydrograph, factors affecting Hydrograph, Unit Hydrograph.					
Unit-II	**Estimation of Flood**				**08 Hrs.**
Flood Estimation: Rational Method, Empirical formula, flood frequency studies, Gumbel's method, Log-Pearson type III Distribution, Design flood: Spillway Design Flood, Standard Project Flood (SPF), Probable Maximum Flood (PMF) Risk, reliability and safety factor.					
Unit-III	**Flood Routing**				**08 Hrs.**
Flood Routing: Introduction, basic equation, and hydrologic channel routing, Hydraulic method of flood routing, Flood control.					
Unit-IV	**Drought**				**08 Hrs.**
Introduction: Drought and types of drought, Cause of drought, Drought in India, Effects on water resources.					
Unit-V	**Flood and Drought Management**				**08 Hrs.**
Introduction: Flood management measures, structural measures for flood management, Non-structural measures for flood management, prevention from drought.					

References:

1. K Subramanya,"Engineering hydrology",Tata McGraw Hill, New Delhi.
2. Garg S.K., "Hydrology and Water Resources Engineering- vol.1",Khanna publisher, New Delhi.
3. Raghunath, H.M., Hydrology – Principles, Analysis and Design, 1986", Wiley Eastern Ltd., New Delhi..
4. Modi,P.N.,"Irrigation Water Resources and Water Power Engineering", Standard Book House, New Delhi.

Web links to e-learning:

1. https://nptel.ac.in/courses/105101002/
2. https://nptel.ac.in/courses/105101010/

CE563/CEE563	EXPERIMENTAL METHODS IN WATER RESOURCES ENGINEERING				
Pre-requisite	**Co-Requisite**	**L**	**T**	**P**	**C**
	NIL	0	0	3	2

1. Analysis of Precipitation Data
2. Determination of Yield from A Catchment
3. Derivation of Unit Hydrograph
4. Estimation of Design Flood
5. Regional Flood Frequency Analysis
6. Hydrologic and Hydraulic flood routing
7. Derivation of Synthetic Unit Hydrograph
8. Computation of Backwater and Drawdown Curves
9. Analysis of Water Distribution Networks

References:

1. Chow, V.T, Maidment, D.R, and Mays, L.W, Applied Hydrology, Tata McGraw Hill Edition, 2010.
2. McCuen R.H, Hydrologic Analysis and Design, Prentice Hall Inc. New York, 2005.
3. Terry Sturm, Open Channel Hydraulics, Tata McGraw Hill Pub., 2011.
4. Warren Viessman, Jr., and Lewis G.L, Introduction to Hydrology, Prentice Hall India Pvt. Ltd., NewDelhi, 2008.

CE565/CEE565	APPLIED HYDROLOGY				
Pre-requisite	**Co-Requisite**	**L**	**T**	**P**	**C**
	NIL	3	1	0	4
Objective	To analyse the water budget and plan strategies for water conservation and management				
Unit-I	**Fundamentals of Hydrology**				**08 Hrs.**
Hydrologic cycle, systems concept, hydrologic model classification; Reynold's Transport Theorem, continuity, momentum, and energy equations; Atmospheric hydrology: atmospheric circulation, water vapor, formation and forms of precipitation, precipitable water, monsoon characteristics in India.					
Unit-II	**Methods of Estimating Rainfall Losses**				**08 Hrs.**
Thunderstorm Cell model, IDF relationships; factors affecting evaporation, estimation and measurement of evaporation, energy balance method, aerodynamic method, Priestley Taylor method, and pan evaporation; Surface Water: Catchment storage concept.					
Unit-III	**Runoff Estimation**				**08 Hrs.**
Hortonian and saturation overland flow, stream flow hydrographs, base flow separation, index, ERH & DRH, algorithm for abstraction using Green Ampt equation, SCS method, overland and channel flow modeling, time area concepts, and stream net works; Unit Hydrograph: General hydrologic system model, response functions of a linear hydrologic systems and their interrelationships.					
Unit-IV	**Unit Hydrograph**				**08 Hrs.**
convolution equation; definition and limitations of a UH; UH derivation from single and complex storms; UH optimization using regression, matrix, and LP methods; Synthetic unit hydrograph, S-Curve, IUH; Subsurface Water: Soil moisture, porosity, saturated and unsaturated flow.					
Unit-V	**Ground Water Hydrology**				**08 Hrs.**
Richards' equation, infiltration, Horton's, Philip's, and Green Ampt methods, parameter estimation, ponding time concepts; Groundwater Hydrology: Occurrence of groundwater, aquifers & their properties, Darcy's law, permeability, transmissibility, stratification, confined groundwater flow.					

References:

1. K subramanya "*Engineerign Hydrology* ", McGraw Hill.; 7th Edition 2012
2. V T Chow , "*Apploed hydrology",* McGraw Hill Education; 3rd Edition 1981
3. F.M.White "*Fluid Mechanics ",* Mc-Graw Hill Publications,1st Edition Reprint 2007

Web links to e-learning:

1. http://nptel.ac.in/courses/105105105/
2. http://nptel.ac.in/downloads/105105104/

CE566/CEE566	OPEN CHANNEL HYDRAULICS				
Pre-requisite	**Co-Requisite**	**L**	**T**	**P**	**C**
	NIL	3	1	0	4
Objective	To calculate the flow depth and discharge for use in canal design and other hydraulic structures.				
Unit-I	**Uniform Flow**				**08 Hrs.**
Uniform flow ,Manning's equation ,Chezy;s method ,most efficient sections ,non rectangular channels, flow depth and discharge calculation.					
Unit-II	**Gradually Varied Flow**				**08 Hrs.**
Gradually varied flow functions, standard tables, governing differential equations, Bressi's method, GVF profiles, GVF computations.					
Unit-III	**Rapidly Varied Flow**				**08 Hrs.**
Hydraulic jump in sloping and rectangular channels, non rectangular channels, overflow spillway, eddi formation, effect on hydraulic structures.					
Unit-IV	**Unsteady Flow**				**08 Hrs.**
SPH simulations, unsteady flow, surges, surge tank, water hammer, St. Venant equations, Hydraulic flood routing.					
Unit-V	**Ground Water Hydrology**				**08 Hrs**
Design of canals, Theories of design, apron design, design of spillway, design of labyrinth spillway.					

References:

1. K subramanya "open channel flow ", McGraw Hill.; 7th Edition 2012
2. V T Chow , "*open channel hydraulics ",* McGraw Hill Education; 3rd Edition 1981
3. F.M.White "*Fluid Mechanics ",* Mc-Graw Hill Publications,1st Edition Reprint 2007

Web links to e-learning:

1. https://nptel.ac.in/courses/105105105/
2. https://nptel.ac.in/downloads/105105104/

CE568/CEE568	CLIMATE CHANGE IMPACTS IN WATER RESOURCES ENGINEERING				
Pre-requisite	**Co-Requisite**	**L**	**T**	**P**	**C**
	NIL	3	1	0	4
Objective	• To learn about the climate change, their impacts on water resources. • To learn about the climate change adaptation and mitigation measures.				
Unit-I	**Climate System**				**08 Hrs.**
Definitions- Climate, Climate system, climate change – Drivers of Climate change – Characteristics of climate system, components - Greenhouse effect, Carbon cycle, Wind systems-Trade Winds and the Hadley Cell– Ozone hole in the stratosphere - El Nino, La Nina.					
Unit-II	**Impacts of Climate Change**				**08 Hrs.**
Precipitation (including extremes) - water vapor - Snow and land ice - Sea level – Evapotranspiration - Soil moisture – Runoff and river discharge - Patterns of large-scale variability- Influences of hydrological changes on climate - Land surface effects - Projected changes in climate.					
Unit-III	**Impacts and Responses**				**08 Hrs.**
Observed climate change impacts - effects due to changes in the cryosphere - Future changes in water availability and demand due to climate change - Climate-related drivers of freshwater systems in the future - Impacts of climate change on water stress in the future - Impacts of climate change on costs and other socio-economic aspects of freshwater.					
Unit-IV	**Climate Change Adaptation**				**08 Hrs.**
Water-related adaptation to climate change in the fields of Ecosystems and biodiversity, - Agriculture and food security, land use and forestry, Human health, water supply and sanitation, infrastructure and Economy (insurance, tourism, industry and transportation) - Adaptation, vulnerability and sustainable development.					
Unit-V	**Climate Change Mitigation Measures**				**08 Hrs.**
Sector-specific mitigation - Carbon dioxide capture and storage (CCS) , Bio-energy crops, Biomass electricity, Hydropower, Geothermal energy, Energy use in buildings, Land-use change and management, Cropland management, A forestation and Reforestation, - Effects of water management policies and measures on GHG emissions and mitigation - Potential water resource conflicts between adaptation and mitigation - Implications for policy and sustainable development.					

References:

1. Jan C. Van Dam, Impacts of Climate Change and Climate Variability on Hydrological Regimes, Cambridge University Press, 2003.
2. Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds., 'Climate Change and Water'. Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva, 2008.
3. IPCC Report Technical Paper VI – Climate change and water, 2008.
4. P R Shukla, Subobh K Sarma, NH Ravindranath, Amit Garg and Sumana Bhattacharya, Climate Change and India:Vulnerability assessment and adaptation, University Press (India) Pvt Ltd, Hyderabad

Web links to e-learning:

1. https://nptel.ac.in/courses/119/106/119106008/
2. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/119106008/lec40.pdf

CE567/CEE567	COMPUTER METHODS IN HYDRAULICS AND HYDROLOGY				
Pre-requisite	**Co-Requisite**	**L**	**T**	**P**	**C**
	NIL	0	0	3	2

1. Introduction to computer programming and computation with MATLAB. Open channel flow : Estimation of normal and critical depth; uniform flow computations; computation of water surface profile (WSP) gradually varied flow estimation using standard step and direct step methods,
2. WSP in presence of hydraulic structures; unsteady flow Saint Venant equation, kinematic wave routing, diffusion routing, overland flow; steady and unsteady modeling using HECRAS.
3. Closed conduit flow: Steady and unsteady state modeling; pipe network analysis; introduction to EPANET/Water CAD. Surface water hydrology:
4. Estimation of Unit hydrographs; lumped and distributed flow routing; hydrologic statistics parameter estimation, time series analysis, frequency analysis, geo-statistics; hydrologic modeling using HECHMS.
5. Groundwater hydrology: Solving groundwater flow equation saturated and unsaturated flow, Richards' equation, Green Ampt infiltration model; introduction to MODFLOW;
6. Application of soft computing methods and GIS in Hydraulic and Hydrologic modeling. Laboratory: Programming exercises for the related topics.

References:

1. Chow, V.T, Maidment, D.R, and Mays, L.W, Applied Hydrology, Tata McGraw Hill Edition, 2010.
2. McCuen R.H, Hydrologic Analysis and Design, Prentice Hall Inc. New York, 2005.
3. Terry Sturm, Open Channel Hydraulics, Tata McGraw Hill Pub., 2011.
4. Warren Viessman, Jr., and Lewis G.L, Introduction to Hydrology, Prentice Hall India Pvt. Ltd., NewDelhi, 2008.
5. Mujumdar, P.P. and D. Nagesh Kumar, Floods in a Changing Climate – Hydrologic Modeling, Cambridge University Press, New York, 2012.
6. Terry Sturm, “Open Channel Hydraulics”, Tata McGraw Hill Pub, 2011.

CE552/CEE552	RESEARCH METHODOLOGY				
Pre-requisite	**Co-Requisite**	**L**	**T**	**P**	**C**
NIL	NIL	3	1	0	4
Objectives	• To develop critical thinking and understand the concept of gap identification for research. • To identify appropriate research methods for a specific research problem and prepare professional research report				
Unit-I	**Introduction to Research and Problem Definition**				**08 Hrs**
Meaning, Objective and importance of research, Types of research, research process, Challenges in research, Philosophical worldviews in research.					
Unit-II	**Research Design**				**08 Hrs**
Research design, Methods of research design, Selection of a Research Design research process and steps involved, Literature Survey, Bibliometric analysis.					
Unit-III	**Data Collection**				**08 Hrs**
Sample Design, Sampling Methods, sampling errors, Classification of Data, Measurement and Scaling, Methods of Data Collection, data preparation.					
Unit-IV	**Data Analysis and interpretation**				**08 Hrs**
Data analysis, Statistical techniques and choosing an appropriate statistical technique, Hypothesis, Hypothesis testing, Data processing software (e.g. SPSS etc.), statistical inference, Interpretation of results.					
Unit-V	**Technical Writing and Reporting of Research**				**08 Hrs**
Types of research report: Dissertation and Thesis, research paper, review article, short communication, conference presentation etc., Referencing and referencing styles, Mechanics of writing a report, Research Journals, Indexing and citation of Journals, Intellectual property, Plagiarism, Oral Presentation.					

References:

1. Creswell, J. W., & Creswell, J. D. (2017). Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications.
2. Sekaran, U., & Bougie, R. (2016). Research methods for business: A skill building approach. John Wiley & Sons.
3. C. R. Kothari, Gaurav Garg,

Web links to e-learning:

1. https://nptel.ac.in/courses/121/106/121106007/
2. https://onlinecourses.nptel.ac.in/noc19_ge21/preview