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				Evaluation Scheme				Subject Total
				L	T	P	C	Continuous Assessment (CA)			Exam ESE	
								CT	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	As per Annexure	Departmental 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				**12**	**4**	**3**	**18**					**500**

Semester – II

S. No.	Course Category	Code No	Name of Subject	Periods				Evaluation Scheme				Subject Total
				L	T	P	C	Continuous Assessment (CA)			Exam ESE	
								CT	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				**9**	**3**	**3**	**18**					**500**

L – Lecture; **T –** Tutorial; **P –** Practical; **C** – Credits; **CT** – Class Tests; **TA** – Teacher Assessment
Continuous Assessment (CA) = Class Tests + Teacher Assessment

Subject Total = Continuous Assessment (CA) + End Semester Examination (ESE)

DC – Departmental Core **DE** – Departmental Elective

Departmental Elective – I

CE555 Mathematics and Statistics for Hydraulic Engineering

CE558 Modeling Simulation and Optimization

CE560 Advanced Numerical Analysis

CE561 Flood and Drought

Integral University, Lucknow

Effective from Session: 2019-20							
Course Code	CE566	**Title of the Course**	Open Channel Hydraulics	**L**	**T**	**P**	**C**
Year	I	**Semester**	I	3	1	0	4
Pre-Requisite	NIL	**Co-requisite**	NIL				
Course Objectives	• To calculate the flow depth and discharge for use in canal design and other hydraulic structures.						

Course Outcomes	
CO1	Students will learn the type of flow, Different types of equation, Types of Channels and Discharge Calculation.
CO2	Students will learn about the gradually varied flow function and GVF profiles and GVF computations.
CO3	Students will learn about the various type of jump in sloping and rectangular channels and effect on hydraulic structures
CO4	The learner will learn about SPH simulations, unsteady flow, surges, surge tank, water hammer, St. Venant equations, Hydraulic flood routing
CO5	To learn the Design of canals, Theories of design, apron design, design of spillway, design of labyrinth spillway

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Uniform Flow	Uniform flow, Manning's equation, Chezy;s method ,most efficient sections, non rectangular channels, flow depth and discharge calculation.	08	CO1
2	Gradually Varied Flow	Gradually varied flow functions, standard tables, governing differential equations, Bressi's method, GVF profiles, GVF computations	08	CO2
3	Rapidly Varied Flow	Hydraulic jump in sloping and rectangular channels, non-rectangular channels, overflow spillway, eddy formation, effect on hydraulic structures	08	CO3
4	Unsteady Flow	SPH simulations, unsteady flow, surges, surge tank, water hammer, St. Venant equations, Hydraulic flood routing.	08	CO4
5	Ground Water Hydrology	Design of canals, Theories of design, apron design, design of spillway, design of labyrinth spillway.	08	CO5

Reference Books:

K Subramanya "open channel flow ", McGraw Hill.; 7th Edition 2012

V T Chow , "*open channel hydraulics ",* McGraw Hill Education; 3rd Edition 1981

F.M.White "*Fluid Mechanics ",* Mc-Graw Hill Publications,1st Edition Reprint 2007

e-Learning Source:

https://nptel.ac.in/courses/105105105/

https://nptel.ac.in/downloads/105105104/

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	2	1	1	2	2	1	1	1	2	1	1	1
CO2	2	1	2	2	1	1	2	1	1	2	2	1	1	1
CO3	1	1	1	2	2	2	1	1	2	2	1	1	1	1
CO4	1	2	2	1	1	1	2	1	1	1	2	1	1	1
CO5	1	1	1	1	2	2	1	1	2	1	2	2	1	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2019-20							
Course Code	CE556	**Title of the Course**	Water Resources Systems Planning and Management	**L**	**T**	**P**	**C**
Year	I	**Semester**	I	3	1	0	4
Pre-Requisite	NIL	**Co-requisite**	NIL				
Course Objectives	• To understand Principles of Systems Analysis in Water Resources Engineering, Resources Planning and Development, Nature of Water Resources Systems and Socio Economic Characteristics • To understand the Principles of Engineering Economy, Capital, Economic and Financial Evaluation and Socio-Economic Analysis • To understand Linear Programming Models, Simplex Method, Sensitivity Analysis, Dual Programming, Optimization Techniques, Simulation and Multi Objective Optimization. • To understand the Surface Water Storage Requirements, Storage Capacity, Hydropower and Flood Control, Reservoir Operations, Irrigation and Planning of an Irrigation System. • To understand concept of Groundwater management, Conjunctive Use of Water Resources and Design of Water Conveyance and Distribution Systems.						

Course Outcomes	
CO1	Students will be able to explain the principles of system analysis and nature of water resources system.
CO2	Students will be able to understand the engineering economy and able to understand the financial evaluation.
CO3	Students will be able to understand Linear Programming Models and methods of analysis.
CO4	Students will be able to understand the Requirements of Surface Water Storage Hydropower and flood control.
CO5	Students will be able to understand Groundwater management, Conjunctive Use of Water Resources and design of water conveyance and distribution systems.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Introduction	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.	08	CO1
2	Economic Analysis of Water Resources System	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.	08	CO2
3	Methods of Systems Analysis	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.	08	CO3
4	Water Quantity Management	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.	08	CO4
5	Design of Systems	Groundwater management, Conjunctive Use of Surface and Subsurface Water Resources, Reservoir Design, Design of Water Conveyance and Distribution Systems.	08	CO5

Reference Books:

Chaturvedi, M.C. “Water Resources Systems Planning and Management”, Tata McGraw Hill Pub. Co., N Delhi.

Hall. W.A. and Dracup, J.A. “Water Resources Systems”, Tata McGraw Hill Pub. N Delhi.

James, L.D. and Lee “Economics of Water Resources Planning”, McGraw Hill Inc. N York.

Kuiper, E. “Water Resources Development, Planning, Engineering and Economics”, Buttersworth, London.

Biswas, A.K. “Systems Approach to Water Management”, McGraw Hill Inc. N York.

e-Learning Source:

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

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO / **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	0	0	0	0	1	0	2	1	0	0	0	0
CO2	2	1	0	0	1	0	0	0	0	0	3	1	0	0
CO3	1	1	3	2	0	0	0	0	1	0	2	0	0	0
CO4	2	2	0	0	0	0	2	0	2	0	0	2	0	0
CO5	2	2	3	1	0	0	2	0	1	0	1	2	0	0

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2019-20							
Course Code	CE557	**Title of the Course**	Advanced Hydraulic Engineering	**L**	**T**	**P**	**C**
Year	I	**Semester**	I	3	1	0	4
Pre-Requisite	NIL	**Co-requisite**	NIL				
Course Objectives	• To understand the hydraulic engineering principle in various problems of practical world						

Course Outcomes	
CO1	Students are able to understand basic concept of properties of fluid and its application
CO2	Students will learn about basic principle of Gradually Varied flow (GVF), Channel Contractions and its applications
CO3	To apply dimensional analysis to predict physical parameters of model and prototype. To learn the Navies Stokes Equation, Bernoulli's and Euler's equation and its applications.
CO4	To understand the Finite element method, application to potential flow problems, and application to transient problems.
CO5	To understand the concept of Stream function, velocity potential, and Flow dynamics.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Fundamentals of Fluid Flow	Fluid properties, Forces on immersed bodies, buoyancy, meta centre, flow measurement, shear and normal forces, lift and drag force	08	CO1
2	Free Surface Flows	Free surface equation, governing principles, flow over the hump, width contraction, elevation and transition, GVF profiles, hydraulic jump.	08	CO2
3	Dimensional Analysis	Dimensional analysis and similitude, Buckingham pi theorem, similarity laws, laminar and turbulent flows, navier stokes equation, Bernaulli's and eulers equation	08	CO3
4	Finite Element Method	Finite element method theory, derivation, application to potential flow problems, source sink, application to transient problems, shape functions	08	CO4
5	Potential Flow Theory	Stream function, velocity potential, Gama and beta function, application to seepage problems, flow dynamics, Darcy's law. Ground water flow	08	CO5

Reference Books:

A.K..Jain "*Fluid Mechanics* ", Nem Chand & Bros.; 7th Edition 2012

Modi and seth , "Fluid Mechanics", McGraw Hill Education; 3rd Edition 20

F.M.White "Fluid Mechanics ", Mc-Graw Hill Publications,1st Edition Reprint 2007

e-Learning Source:

https://nptel.ac.in/courses/105105105/

https://nptel.ac.in/downloads/105105104/

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	3	2	3	2	2	1	3	2	3	2	1	2	2
CO2	2	2	2	2	3	2	3	2	2	2	1	1	2	2
CO3	2	3	1	3	2	3	3	2	3	1	2	2	2	2
CO4	3	2	2	2	1	2	3	2	2	2	1	1	2	2
CO5	1	2	2	2	2	2	2	2	1	2	1	1	2	2

1- Low Correlation; 2- Moderate Correlation; 3- 1Substantial Correlation

Integral University, Lucknow

Effective from Session: 2023-24							
Course Code	CE555	**Title of the Course**	Mathematics and Statistics for Hydraulic Engineering	**L**	**T**	**P**	**C**
Year	I	**Semester**	I	3	1	0	4
Pre-Requisite	NIL	**Co-requisite**	NIL				
Course Objectives	To develop the necessary mathematical aptitude as relevant to hydraulic engineers.						

Course Outcomes	
CO1	To understand the basic concept of linear algebra and basic calculus
CO2	To understand the basic Statistical Properties of data.
CO3	To learn about the probability distributions and their applications in the hydraulic engineering field.
CO4	To learn about the frequency analysis, risk and uncertainty in Hydroclimatic analysis.
CO5	To understand the basic concept of method of least square, correlation and regression.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Linear Algebra and Calculus	Eigen values and Eigen vectors, solution of linear equations, Multiple integration, spherical coordinate systems, ordinary differential equations and partial differential equations	08	CO1
2	Basic Statistical Properties of data	Descriptive Statistics, Concept of Moments and Expectation, Moment-Generating Functions, Characteristic Functions, Statistical Properties of Jointly Distributed Random Variables, Properties of the Estimator, Parameter Estimation	08	CO2
3	Probability distributions and their applications	Discrete Probability Distributions: Binomial Distribution, Geometric Distribution and Poisson Distribution. Continuous Probability Distributions: Uniform Distribution, Exponential Distribution, Normal Distribution, Lognormal Distribution, Gamma Distribution.	08	CO3
4	Frequency analysis, risk and uncertainty in Hydroclimatic analysis	Concept of Return Period, Frequency Analyses of Hydroclimatic Extremes, Risk and Reliability in Hydrologic Design, Concept of Uncertainty, Reliability, Resilience, and Vulnerability of Hydrologic Time Series	08	CO4
5	Method of least square, correlation and regression Analysis	Method of least square: Principle and method of least squares, change of scale in second degree equation. Correlation: introduction and Types of correlations, types of distribution, covariance, Karl Pearson's coefficient of correlation, Coefficient of correlation of Grouped data, Spearman's Rank correlation. Regression**:** line of regression, equation to the lines of relation, multiple regression, error of prediction. Calculation of multiple correlation coefficient	08	CO5

Reference Books:
Shanti Narayan: A Text Book of Martices, S. Chand & Co.
Thomas/Finny: Calculus and Analytical Geometry, Narosa Pub.
B.S. Grewal: Higher Engineering Mathematics, Khanna Publishers.
Jaggi and Mathur: Advanced Engineering Mathematics, Khanna Pub
Rajib Maity: Statistical Methods in Hydrology and Hydroclimatology, Springer.
e-Learning Source:
http://nptel.ac.in/courses/105105105/
http://nptel.ac.in/downloads/105105104/
https://link.springer.com/book/10.1007/978-981-10-8779-0

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO / **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	2	2	0	0	0	0	0	1	0	0	2	2
CO2	2	1	2	1	0	0	0	0	0	0	0	0	2	2
CO3	1	3	2	2	0	0	0	0	0	1	2	0	2	3
CO4	3	2	0	2	0	0	0	0	0	0	2	0	2	3
CO5	2	2	2	2	0	0	0	0	0	0	3	0	2	3

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2019-20							
Course Code	CE558	**Title of the Course**	Modeling Simulation and Optimization	**L**	**T**	**P**	**C**
Year	I	**Semester**	I	3	1	0	4
Pre-Requisite	NIL	**Co-requisite**	NIL				
Course Objectives	To understand the Concepts of systems and systems analysis, Linear programming, Dynamic programming, Simulation Multi-objective planning and optimization of hydropower systems						

Course Outcomes	
CO1	Students will learn about the system and types of system, optimization, functions of variable and constrained optimization
CO2	Students will learn about the linear programming and Graphics method, simplex method, multiple solutions, unbounded and infeasible problems
CO3	Students will learn about the dynamic programming and different types of problems (Water allocation problem, reservoir operation problem, capacity and expansion and shortest route problem.
CO4	Students will learn about the Simulation, Multi objective planning, Fuzzy optimization for water quality control and reservoir operation
CO5	Students will learn about the Conjunctive use of ground and surface water, hydropower optimization, crop yield optimization, multi-basin and multi –reservoir system

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Introduction and Optimization	Introduction: Definition and types of system, optimization: functions of a single variable , functions of a multiple variables, constrained optimization	08	CO1
2	Linear Programming	Introduction to linear programming: graphics method, simplex method, multiple solutions, unbounded and infeasible problems, dual problem	08	CO2
3	Dynamic Programming	Introduction to dynamic programming: water allocation problem, reservoir operation problem, capacity and expansion and shortest route problem.	08	CO3
4	Simulation, Objective Planning and Fuzzy Optimization	Simulation: introduction to multi – objective planning, Multi objective planning, Fuzzy optimization for water quality control and reservoir operation.	08	CO4
5	Model formulations and case studies	Conjunctive use of ground and surface water, hydropower optimization, crop yield optimization, multi-basin and multi – reservoir system	08	CO5

Reference Books:

Loucks, D.P. and Eelco van Beek (2005). Water resources systems planning and management: An introduction to methods, models and applications. UNESCO

Vedula, S. and Mujumdar, P.P. (2005). Water resources systems: Modeling techniques and analysis, Tata McGraw Hill, New Delhi

Mays, L.W. and Tung, Y.K. (1992). Hydrosystems engineering and management, McGraw Hill, USA

Simonovic, S.P. (2009). Managing water resources: Methods and tools for a systems approach, UNESCO publishing, France

e-Learning Source:

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

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	1	1	0	0	0	0	1	0	1	1	2	3
CO2	2	3	2	2	0	1	0	0	1	1	1	1	2	3
CO3	2	3	2	2	0	1	0	0	1	1	1	1	2	3
CO4	2	3	1	2	0	1	0	0	1	1	0	1	2	3
CO5	2	1	0	1	0	1	1	0	1	1	1	2	2	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2019-20							
Course Code	CE560	**Title of the Course**	Advanced Numerical Analysis	**L**	**T**	**P**	**C**
Year	I	**Semester**	I	**3**	**1**	**0**	**4**
Pre-Requisite	NIL	**Co-requisite**	NIL				
Course Objectives	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.						

Course Outcomes	
CO1	To enable the student to learn various types of curves fitting methods.
CO2	To enable the students to Solve initial and boundary value problems in differential equations using numerical methods.
CO3	To give the knowledge to Integrate the function using General Quadrature formula on errors.
CO4	To learn the numerical solutions of system of linear equations and check the accuracy of the solutions.
CO5	To learn the solutions of simultaneous Linear Systems of Equations.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Curve Fitting	Least – Squares curve fitting procedures, fitting a straight line, nonlinear curve fitting, Curve fitting by a sum of exponentials.	08	CO1
2	Numerical Differentiation	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	08	CO2
3	Numerical Integration	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	08	CO3
4	Solutions of simultaneous Linear Systems of Equations	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	08	CO4
5	Numerical solution of ordinary differential equations	Introduction, Solution by Taylor's Series, Picard's method of successive approximations, Euler's method, Modified Euler's method, Runge – Kutta methods	08	CO5

Reference Books:

Numerical Analysis by S.S.Sastry, published by Prentice Hall India (Latest Edition).(2015)

Numerical Analysis by G. Sankar Rao, published by New Age International Publishers, New – Hyderabad.(2006)

Finite Differences and Numerical Analysis by H.C Saxena published by S. Chand and Company, Pvt. Ltd., New Delhi.(2009)

Numerical methods for scientific and engineering computation by M.K.Jain, S.R.K.Iyengar, R.K. Jain.(2002)

e-Learning Source:

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

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	1	3	3	3	1	0	0	1	0	0	2	2	3
CO2	1	2	2	2	2	1	0	0	1	0	0	1	2	3
CO3	1	2	3	3	3	2	0	0	1	0	0	1	2	3
CO4	1	1	2	2	3	2	0	0	1	0	0	1	2	3
CO5	1	1	2	2	3	3	0	0	1	0	0	1	2	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2019-20							
Course Code	CE561	**Title of the Course**	Flood and Drought	**L**	**T**	**P**	**C**
Year	I	**Semester**	I	**3**	**1**	**0**	**4**
Pre-Requisite	NIL	**Co-requisite**	NIL				
Course Objectives	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.						

Course Outcomes	
CO1	To understand the basic concept of Flood, factor affecting flood, Runoff, factors affecting runoff, estimation of runoff, Flood Hydrograph, factors affecting Hydrograph, Unit Hydrograph.
CO2	To understand the basic concept of methods of Estimation of flood, Probable Maximum Flood (PMF) Risk, reliability and safety factor.
CO3	To understand the basic concept of Flood Routing**,** and hydrologic channel routing, Hydraulic method of flood routing and Flood control.
CO4	To understand the basic concept of Drought and their types, Cause of drought, Drought in India, Effects on water resources.
CO5	To understand the basic Flood management measures, structural measures for flood management, Non-structural measures for flood management, prevention from drought.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Introduction	Flood: Introduction, types, factor affecting flood, Runoff: Introduction, factors affecting runoff, estimation of runoff. Hydrograph: Flood Hydrograph, factors affecting Hydrograph, Unit Hydrograph.	08	CO1
2	Estimation of Flood	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.	08	CO2
3	Flood Routing	Flood Routing: Introduction, basic equation, and hydrologic channel routing, Hydraulic method of flood routing, Flood control.	08	CO3
4	Drought	Introduction: Drought and types of drought, Cause of drought, Drought in India, Effects on water resources.	08	CO4
5	Flood and Drought Management	Introduction: Flood management measures, structural measures for flood management, Non-structural measures for flood management, prevention from drought	08	CO5

Reference Books:

K Subramanya, "Engineering hydrology", Tata McGraw Hill, New Delhi

Garg S.K., "Hydrology and Water Resources Engineering- vol.1",Khanna publisher, New Delhi.

Raghunath, H.M., Hydrology – Principles, Analysis and Design, 1986", Wiley Eastern Ltd., New Delhi..

Modi,P.N.,"Irrigation Water Resources and Water Power Engineering", Standard Book House, New Delhi.

e-Learning Source:

https://nptel.ac.in/courses/105101002/

https://nptel.ac.in/courses/105101010/

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	1	1	0	2	2	0	0	0	0	0	3	2
CO2	2	2	1	2	0	3	1	0	2	0	1	2	3	2
CO3	2	2	1	2	0	3	2	0	2	0	1	2	3	2
CO4	2	1	1	1	0	2	3	0	0	0	1	1	3	2
CO5	2	2	1	1	0	2	2	0	2	0	1	2	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2019-20							
Course Code	CE563	**Title of the Course**	Experimental Methods in Water Resources Engineering	**L**	**T**	**P**	**C**
Year	I	**Semester**	I	0	0	3	2
Pre-Requisite		**Co-requisite**					
Course Objectives	To give the experimental knowledge and analysis skill to the students so that the students can use that knowledge in the water resources engineering.						

Course Outcomes	
CO1	Students will be able to understand the analysis of Precipitation data.
CO2	Students will be able to understand about the Catchment area.
CO3	Students will be able to understand about the unit hydrograph.
CO4	Students will be able to understand about the Estimation of Design Flood.
CO5	Students will be able to understand about the Flood Frequency Analysis.
CO6	Students will be able to understand about the flood routing.
CO7	Students will be able to understand about the Derivation of Synthetic Unit Hydrograph.
CO8	Students will be able to understand about the Computation of Backwater and Drawdown Curves.
CO9	Students will be able to understand about the Analysis of Water Distribution Networks.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Experiment I	Analysis of Precipitation Data,	03	CO1
2	Experiment II	Determination of Yield from A Catchment	03	CO2
3	Experiment III	Derivation of Unit Hydrograph	03	CO3
4	Experiment IV	Estimation of Design Flood	03	CO4
5	Experiment V	Regional Flood Frequency Analysis	03	CO5
6	Experiment VI	Hydrologic and Hydraulic flood routing	03	CO6
7	Experiment VII	Derivation of Synthetic Unit Hydrograph	03	CO7
8	Experiment VIII	Computation of Backwater and Drawdown Curves	03	CO8
9	Experiment IX	Analysis of Water Distribution Networks	03	CO9

Reference Books:

Chow, V.T, Maidment, D.R, and Mays, L.W, Applied Hydrology, Tata McGraw Hill Edition, 2010.

McCuen R.H, Hydrologic Analysis and Design, Prentice Hall Inc. New York, 2005.

Terry Sturm, Open Channel Hydraulics, Tata McGraw Hill Pub., 2011.

Warren Viessman, Jr., and Lewis G.L, Introduction to Hydrology, Prentice Hall India Pvt. Ltd., NewDelhi, 2008

e-Learning Source:

https://nptel.ac.in/courses/105107129

https://nptel.ac.in/courses/105101002

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO / **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	3	1	0	0	0	0	0	0	0	0	2	3
CO2	3	2	3	1	0	0	0	0	0	0	0	0	2	3
CO3	3	1	3	2	0	0	0	0	0	0	0	0	2	3
CO4	3	1	3	1	0	0	0	0	0	0	0	0	2	3
CO5	3	1	3	1	0	0	0	0	0	0	0	0	2	3
CO6	3	3	3	2	0	0	0	0	0	0	0	0	2	3
CO7	3	2	3	0	0	0	0	0	0	0	0	0	2	3
CO8	3	2	3	0	0	0	0	0	0	0	0	0	2	3
CO9	3	1	3	0	0	0	0	0	0	0	0	0	23	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2019-20							
Course Code	CE565	**Title of the Course**	Applied Hydrology	**L**	**T**	**P**	**C**
Year	I	Semester	II	3	1	0	4
Pre-Requisite	NIL	**Co-requisite**	NIL				
Course Objectives	To analyse the water budget and plan strategies for water conservation and management						

Course Outcomes	
CO1	To understand 'Hydrologic cycle, systems concept, hydrologic model classification; Reynold's Transport Theorem.
CO2	To understand the concept of Thunderstorm Cell model, IDF relationships and measurement of evaporation, energy balance method, ,
CO3	To understand the concept of Hortonian and saturation overland flow, stream flow hydrographs and Unit Hydrograph concept
CO4	To understand the concept of convolution equation; definition and limitations of a UH;
CO5	To understand the basic concept of infiltration and its equation, Groundwater Hydrology, Darcy's law,

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Fundamentals of Hydrology	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.	08	CO1
2	Methods of Estimating Rainfall Losses	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.	08	CO2
3	Runoff Estimation	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 networks; Unit Hydrograph: General hydrologic system model, response functions of a linear hydrologic systems and their interrelationships.	08	CO3
4	Unit Hydrograph	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.	08	CO4
5	Ground Water Hydrology	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	08	CO5

Reference Books:

K subramanya "*Engineerign Hydrology* ", McGraw Hill.; 7th Edition 2012

V T Chow , "*Apploed hydrology",* McGraw Hill Education; 3rd Edition 1981

F.M.White "*Fluid Mechanics ",* Mc-Graw Hill Publications,1st Edition Reprint 2007

e-Learning Source:

http://nptel.ac.in/courses/105105105/

http://nptel.ac.in/downloads/105105104/

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	3	2	2	1	1	2	1	1	1	2	1	0	0
CO2	2	1	2	1	3	1	1	2	1	2	2	2	0	0
CO3	3	1	3	1	2	1	2	1	2	2	1	2	0	0
CO4	2	2	1	2	1	2	2	1	0	1	2	1	0	0
CO5	2	2	2	2	2	2	1	1	2	1	3	2	0	0

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2021-22							
Course Code	CE552	**Title of the Course**	Research Methodology	**L**	**T**	**P**	**C**
Year	I	**Semester**	II	3	1	0	4
Pre-Requisite	NIL	**Co-requisite**	NIL				
Course 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						

Course Outcomes	
CO1	Develop the student's understanding of research methods and applying those methodology to solve complex research problems.
CO2	Develop student's understanding of sampling techniques for research.
CO3	Develop student's understanding of different data collection methods and their suitability.
CO4	Students will gain understanding of analyzing the quantitative data.
CO5	Students will gain understanding of analyzing the qualitative data and will learn how to write a professional research report.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Introduction to Research and Problem Definition	Meaning, Objective and importance of research, Types of research, research process, Challenges in research, Philosophical worldviews in research.	8	CO1
2	Research Design	Research design, Methods of research design, Selection of a Research Design research process and steps involved, Literature Survey, Bibliometric analysis.	8	CO2
3	Data Collection	Sample Design, Sampling Methods, sampling errors, Classification of Data, Measurement and Scaling, Methods of Data Collection, data preparation.	8	CO3
4	Data Analysis and interpretation	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.	8	CO4
5	Technical Writing and Reporting of Research	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.	8	CO5

Reference Books:

C. R. Kothari, Gaurav Garg, Research Methodology : Methods And Techniques, New Age International Publishers; Fourth edition (1 September 2019)

Creswell, J. W., & Creswell, J. D. (2017). Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications.

Sekaran, U., & Bougie, R. (2016). Research methods for business: A skill building approach. John Wiley & Sons.

e-Learning Source:

https://onlinecourses.nptel.ac.in/noc22_ge08/preview

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	0	0	0	0	0	0	0	0	0	0	0
CO2	3	3	2	0	0	0	0	0	0	0	0	0	0	0
CO3	3	3	2	3	0	0	0	0	0	0	0	0	0	0
CO4	3	3	2	3	3	0	0	0	0	0	0	0	0	0
CO5	3	3	0	0	0	0	0	3	0	3	0	0	0	0

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2019-20							
Course Code	CE568	**Title of the Course**	Climate Change Impacts in Water Resources Engineering	**L**	**T**	**P**	**C**
Year	I	**Semester**	II	3	1	0	4
Pre-Requisite	NIL	**Co-requisite**	NIL				
Course Objectives	To learn about the climate change, their impacts on water resources. To learn about the climate change adaptation and mitigation measures.						

Course Outcomes	
CO1	Students are able to understand the climate change and greenhouse gases and carbon cycle.
CO2	Students have ability to understand the precipitation, Evapotranspiration and influences of hydrological changes on climate and Projected changes in climate.
CO3	Students have ability to understand the impact of climate change and Future changes in water availability and demand due to climate change.
CO4	Students are able to understand the impact of climate change in the field of ecosystem and biodiversity.
CO5	Students are able to understand the Sector-specific mitigation, Effects of water management policies, measures on GHG emissions and mitigation

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Climate System	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	08	CO1
2	Impacts of Climate Change	Precipitation (including extremes) - water vapor - Snow and land ice - Sea level – Evapotranspiration - Soil moisture – Runoff and river discharge - Patterns of largescale variability- Influences of hydrological changes on climate - Land surface effects - Projected changes in climate.	08	CO2
3	Impacts and Responses	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.	08	CO3
4	Climate Change Adaptation	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.	08	CO4
5	Climate Change Mitigation Measures	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.	08	CO5

Reference Books:

Jan C. Van Dam, Impacts of Climate Change and Climate Variability on Hydrological Regimes, Cambridge University Press, 2003.

Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutik of, Eds., 'Climate Change and Water'. Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva, 2008.

IPCC Report Technical Paper VI – Climate change and water, 2008.

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.

e-Learning Source:

https://nptel.ac.in/courses/119/106/119106008/

https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/119106008/lec40.pdf

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO / **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	0	0	0	0	2	2	0	2	0	0	0	2	1
CO2	2	1	0	1	0	0	3	0	0	2	0	2	1	3
CO3	2	2	0	2	2	2	3	0	1	2	0	0	2	3
CO4	2	2	2	2	0	2	3	1	2	0	0	0	1	3
CO5	2	1	0	2	0	2	2	1	1	2	1	1	2	3

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2019-20							
Course Code	CE572	**Title of theCourse**	Research Paper Presentation and Discussion /Seminar	**L**	**T**	**P**	**C**
Year	I	**Semester**	II	0	0	3	2
Pre-Requisite	NIL	**Co-requisite**	NIL				
Course Objectives	• To understand organization of topic for presentation and research. • To learn the skill set required to perform research.						

Course Outcomes	
CO1	Skill to search on any topic to extract the inference.
CO2	Ability to organize – deliver presentation and report on any topic.

Unit No.	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Seminar shall be delivered preferably on the topic of dissertation or at least the area of dissertation. The concepts must be clearly understood and presented by the student. Prior to presentation, he/sheshall carry out the detailed literature survey from Standard References such as International Journals and Periodicals, recently published reference Books etc. All modern methods of presentation should be used by the student. A hard copy of the report (25 to 30 pages) should be submitted to the Department before delivering the seminar. A PDF copy of the report in soft form must be submitted to the supervisor along with other details if any. Supervisor should guide concern student 2hrs /week/student for seminar.	03	CO1 and CO2

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	0	0	0	3	3	1	2	1	3	3	0	3	3	3
CO2	0	0	0	0	3	1	2	1	3	3	0	3	3	3

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2019-20							
Course Code	CE567	**Title of the Course**	Computer Methods in Hydraulics and Hydrology	**L**	**T**	**P**	**C**
Year	I	**Semester**	II	-	-	3	2
Pre-Requisite	NIL	**Co-requisite**	NIL				
Course Objectives	• Students will learn about the computer programming and computation with MATLAB. • Students will learn about the Estimation of Unit hydrographs; lumped and distributed flow routing; hydrologic statistics parameter estimation. • Students will learn about the Application of soft computing methods and GIS in Hydraulic and Hydrologic modeling.						

Course Outcomes	
CO1	Students will be able to understand about the application of MATLAB in Open channel flow for the Estimation of normal and critical depth etc.
CO2	Students will be able to learn about the Estimation of Unit hydrographs; lumped and distributed flow routing; hydrologic statistics parameter estimation.
CO3	Students will be able to learn about the Application of soft computing methods and GIS in Hydraulic and Hydrologic modeling.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Experiment No 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,	08	CO1
2	Experiment No 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.	08	CO1
3	Experiment No 3	Closed conduit flow: Steady and unsteady state modeling; pipe network analysis; introduction to EPANET/Water CAD. Surface water hydrology:	08	CO2
4	Experiment No 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.	08	CO2
5	Experiment No 5	Groundwater hydrology: Solving groundwater flow equation saturated and unsaturated flow, Richards' equation, Green Ampt infiltration model; introduction to MODFLOW;	08	CO3
6	Experiment No 6	Application of soft computing methods and GIS in Hydraulic and Hydrologic modeling. Laboratory: Programming exercises for the related topics.	08	CO3

Reference Books:

Chow, V.T, Maidment, D.R, and Mays, L.W, Applied Hydrology, Tata McGraw Hill Edition, 2010.

McCuen R.H, Hydrologic Analysis and Design, Prentice Hall Inc. New York, 2005

Terry Sturm, Open Channel Hydraulics, Tata McGraw Hill Pub., 2011.

Warren Viessman, Jr., and Lewis G.L, Introduction to Hydrology, Prentice Hall India Pvt. Ltd., New Delhi, 2008.

Mujumdar, P.P. and D. Nagesh Kumar, Floods in a Changing Climate – Hydrologic Modeling, Cambridge University Press, New York, 2012.

Terry Sturm, "Open Channel Hydraulics", Tata McGraw Hill Pub, 2011.

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	0	3	0	3	0	0	0	0	2	0	0	0	0
CO2	2	0	3	0	3	0	0	0	0	2	0	0	0	0
CO3	2	0	3	0	3	0	0	0	0	2	0	0	0	0

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation