Appendix-

DEPARTMENT OF CIVIL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Program Code: **19** **M. Tech. (Hydraulic Engineering)**
Department: **CE** **Civil Engineering**
Year: **I**

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
Semester- I (Autumn)														
1.	CEN-531	Advanced Hydrology	PCC	4	3	1	-	3	-	25	-	25	50	-
2.	CEN-532	Advanced Fluid Mechanics	PCC	4	3	1	2/2	3	-	20	20	20	40	-
3.	CEN-533	Free Surface Flows	PCC	4	3	1	-	3	-	25	-	25	50	-
4.	CEN-534	Modeling, Simulation and Optimization	PCC	4	3	1	-	3	-	25	-	25	50	-
5.		Programme Elective – I	PEC	4	-	-	-	-	-	-	-	-	-	-
		Total		20										
Semester-II (Spring)														
1.	CEN-535	Ground Water Engineering	PCC	4	3	1	-	3	-	25	-	25	50	-
2.	CEN-700	Seminar	SEM	2	0	0	2	-	-	-	-	-	100	-
3.		Programme Elective – II	PEC	4	-	-	-	-	-	-	-	-	-	-
4.		Programme Elective – III	PEC	4	-	-	-	-	-	-	-	-	-	-
5.		Programme Elective – IV	PEC	4	-	-	-	-	-	-	-	-	-	-
		Total		18										

DEPARTMENT OF CIVIL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Program Code: **19** **M. Tech. (Hydraulic Engineering)**
Department: **CE** **Civil Engineering**
Year: **II**

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	**Subject Code**	**Course Title**	**Subject Area**	**Credits**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Semester- I (Autumn)														
1.	CEN-701A	Dissertation Stage–I (to be continued next semester)	DIS	12	-	-	-	-	-	-	-	-	100	-
		Total		12										
Note: Students can take 1 or 2 audit courses as advised by the supervisor, if required.														
Semester-II (Spring)														
1.	CEN-701B	Dissertation Stage–II (contd. From III semester)	DIS	18	-	-	-	-	-	-	-	-	100	-
		Total		18										

Summary				
Semester	1	2	3	4
Semester-wise Total Credits	**20**	**18**	**12**	**18**
Total Credits	**68**			

Program Elective Courses (Hydraulic Engineering)

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1.	CEN-631	Fluvial Hydraulics	PEC	4	3	1	-	3	-	25	-	25	50	-
2.	CEN-632	Hydraulic Structures	PEC	4	3	1	-	3	-	25	-	25	50	-
3.	CEN-633	Systems Engineering	PEC	4	3	1	-	3	-	25	-	25	50	-
4.	CEN-634	Water Resources Systems Planning	PEC	4	3	1	-	3	-	25	-	25	50	-
5.	CEN-635	Irrigation and Drainage	PEC	4	3	1	-	3	-	25	-	25	50	-
6.	CEN-636	Hydro Power Engineering	PEC	4	3	1	-	3	-	25	-	25	50	-
7.	CEN-637	Computational Methods in Fluid Mechanics	PEC	4	3	1	-	3	-	25	-	25	50	-
8.	CEN-614	Theory and Applications of GIS	PEC	4	3	-	2	3	-	15	25	20	40	-
9.	CEN-505	Environmental Hydraulics	PEC	4	3	1	-	3	-	25	-	25	50	-
10.	CEN-521	Advanced Numerical Analysis	PEC	4	3	-	2	3	-	15	25	20	40	-

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE : **Department of Civil Engineering**

1. Subject Code : **CEN-531** Course Title : **Advanced Hydrology**
2. Contact Hours : **L: 3** **T : 1** **P: 0**
3. Examination Duration (Hrs) : **Theory : 3** **Practical : 0**
4. Relative Weight : **CWS : 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits : **4** 6. Semester: **Autumn** 7. Subject Area : **PCC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the fundamentals of hydrological system and mathematical models in surface hydrology.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Hydrologic system and hydrologic budget, fundamental laws of hydrology; atmospheric water vapor.	5
2.	**Hydrologic Inputs:** Precipitation and its forms, snowfall and rainfall; measurement techniques and space-time characteristics	5
3.	**Hydrologic Abstractions:** Infiltration, depression, storage, evapotranspiration; measurement techniques and their modeling	6
4.	**Stream flow:** Measurement techniques, space-time characteristics, rating curves	5
5.	**System Approach:** Unit Hydrograph, IUH, GIUH	6
5.	**Mathematical Modeling**: Linear and Nonlinear models, Physically based models	7
6.	**Hydrological routing**: Flood forecasting, Advance regression and correlation analysis.	5
7.	**Advanced Method of Frequency Analysis**: Outliers, Time series analysis.	3
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE : **Department of Civil Engineering**

1. Subject Code : **CEN-532** Course Title : **Advanced Fluid Mechanics**
2. Contact Hours : **L: 3** **T : 1** **P: 2/2**
3. Examination Duration (Hrs) : **Theory : 3** **Practical : 0**
4. Relative Weight : **CWS : 20** **PRS: 20** **MTE: 20** **ETE: 40** **PRE: 0**
5. Credits : **4** 6. Semester: **Autumn** 7. Subject Area : **PCC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the governing equations, laminar flow, turbulent flow and measurements of turbulence.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Kinematics of Flow:** Equation of continuity in cartesian, polar and cylindrical coordinates, rate of deformation, dilation, vorticity	3
2.	**Standard 2D Flow Patterns:** Source, sink, doublet and their combinations, construction of flows by superposition, D'Alembert's paradox	5
3.	**Laplace Equation:** Solution by graphical and relaxation methods, conformal mapping, solution by separation of variables	4
4.	**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
5.	**Boundary Layers:** Similarity solutions of boundary layer equations, Falkner-Skan Wedge flows, Karman's momentum integral equations, Karman-Puhlhausen approximate solution, separation in boundary layer under adverse pressure gradient, turbulent boundary layer.	8
6.	**Turbulent Flows:** Reynolds equations of motion, semi-empirical theories of turbulence, velocity profiles for inner, outer and overlap layers, equilibrium boundary layers.	8
7.	**Measurement of Turbulence and Statistical Theory of Turbulence:** Isotropic and homogeneous turbulence, probability density functions, correlation coefficients, decay of isotropic turbulence.	6
	Total	**42**

List of Practicals:

1. To study the surface profile and the total head distribution in a forced vortex flow.
2. To study the flow behavior in a pipe bend and to calibrate the pipe bend (i.e., bend or elbow meter) for discharge measurement.
3. To study the boundary layer velocity profile, and to determine the exponent in the power law of velocity distribution, boundary layer thickness and displacement thickness.
4. To study the velocity distribution in an open channel and to estimate the energy and momentum correction factors.
5. To study the characteristics of a hydraulic jump.
6. To study the velocity distribution downstream of an expansion (with and without splitter plates) in a channel.

11. Suggested Books

S. No.	Name of Authors/Books/Publishers	Year of Publication/ Reprint
1.	White, F.M., "Fluid Mechanics", McGraw-Hill.	1979
2.	Schlichting, H., "Boundary Layer Theory", McGraw-Hill.	1979
3.	Garde, R.J., "Turbulent Flow", Wiley Eastern Limited.	1994
4.	Pope, S. B., "Turbulent Flows", Cambridge University Press.	2000
5.	Rouse, H., "Advanced Mechanics of Fluids", John Wiley.	1959
6.	Ojha, C.S.P., Berndtsson, R. and Chandaramouli, P.N., “Fluid Mechanics”, Oxford University Press.	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE : **Department of Civil Engineering**

1. Subject Code : **CEN-533** Course Title : **Free Surface Flows**
2. Contact Hours : **L: 3** **T : 1** **P: 0**
3. Examination Duration (Hrs) : **Theory : 3** **Practical : 0**
4. Relative Weight : **CWS : 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits : **4** 6. Semester: **Autumn** 7. Subject Area : **PCC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the concepts of free surface flow and its applications in flood control, design of drainage and water ways.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Free surface flows, velocity distribution, resistance relationships, specific energy and specific force, normal and critical depths computations, governing equation and computation of gradually varied flows.	6
2.	**Hydraulic Jump:** Elements of hydraulic jump, hydraulic jump in variety of situations including contracting and expanding geometries and rise in floor levels, control of hydraulic jump using baffle walls and cross jets.	6
3.	**Supercritical Flows:** Flow past deflecting boundaries, oblique shock waves.	4
4.	**Spatially Varied Flows:** Flows past side weirs, De Marchi equations, design of side weirs, flow past bottom racks, trench weirs and waste water gutters.	6
5.	**Aerated Flows:** Bulking of flow, mechanism of air entrainments, modelling of aerated flows, development of self-aerated flows, uniform aerated region, aeration over spillway.	6
6.	**Stratified Flows:** Thermal stratification in water bodies including reservoirs, modelling of stratified flows.	4
7.	**Unsteady Flows:** St. Venant's equations and their solution using method of characteristics and finite difference schemes; dam break problem, hydraulic flood routing.	6
8.	**Channel Transitions:** Sub-critical and supercritical.	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/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
4.	Chanson, H., "The Hydraulics of Open Channel Flow: An Introduction", Elsevier.	2004
5.	French, R.H., "Open-Channel Hydraulics", McGraw-Hill.	1994
6.	Wood, I.R., "Air Entrainment in Free-Surface Flows", A.A. balkema.	1991

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE : **Department of Civil Engineering**

1. Subject Code : **CEN-534** Course Title : **Modelling, Simulation and Optimization**
2. Contact Hours : **L: 3** **T : 1** **P: 0**
3. Examination Duration (Hrs) : **Theory : 3** **Practical : 0**
4. Relative Weight : **CWS : 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits : **4** 6. Semester: **Autumn** 7. Subject Area : **PCC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the fundamentals of modeling, simulation and optimization techniques in Civil Engineering
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Systems and Models:** Fundamentals of systemic approach, system modeling, classification of models, model structure, Linear, non-linear, time-invariant, time variant models, State-space models, Distributed parameter models, System Synthesis, Direct and inverse problems, Role of optimization, Role of computers, examples from hydrology/water resources engineering	8
2.	**Regression Analysis:** Linear and Multiple Regression analysis, analysis of residues, tests of goodness of fit, Parsimony criterion, role of historical data, examples from hydrology / water resources engineering.	4
3.	**Spatial Distribution**: Polynomial surfaces, Kirging, Spline functions, Cluster Analysis	4
4.	**Time Series Analysis:** Auto-cross correlation analysis, identification of trend, spectral analysis, identification of dominant cycles, smoothening techniques, Filters, time series of rainfall and stream flow.	6
6.	**Random variables:** Basic concepts, probability density distribution functions, Expectation and standard deviation of discrete and continuous random variables and their functions, covariance and correlation, commonly used theoretical probability distributions (uniform, normal, binomial, poisson's and negative exponential), Fitting distributions to raw data, Chi-square and Kolmogrov-Smirnov;s tests of the goodness of fit, Central limit theorem, various algorithms for generation of random numbers	7
7.	**Monte Carlo simulation:** basic concepts, generation of synthetic observations, statistical interpretation of output, Evaluation of definite integrals,	4
8.	Optimization: Introduction, Classical methods, Linear Programming, Dynamic Programming, Nonlinear optimization, Constrained optimization techniques	9
	Total	**42**

11. Suggested Books

S. No.	Name of Authors/Books/Publishers	Year of Publication/ Reprint
1.	Law, A.M. and Kelton, W.D., "Simulation Modeling and Analysis", Tata McGraw Hill.	2007
2.	Daniel, C. and Wood, P.S., "Fitting Equations to Data", John Wiley.	1980

3.	Ljung, L., "System Identification Theory for the Users", Prentice Hall.	1999
4.	Rao S. S., "Engineering Optimization,Theory and Pratice", New Age International Publishers.	2012
5	Deb, K., "Optimization for Engineering design", Prentice Hall of India.	2006
6	Vedula S. and Mujumdar P. P. "Water Resources Systems", Tata McGraw Hill.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE : **Department of Civil Engineering**

1. Subject Code : **CEN-535** Course Title : **Ground Water Engineering**
2. Contact Hours : **L: 3** **T : 1** **P: 0**
3. Examination Duration (Hrs) : **Theory : 3** **Practical : 0**
4. Relative Weight : **CWS : 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits : **4** 6. Semester: **Spring** 7. Subject Area : **PEC**
8. Pre-requisite: **Nil**

9. Objective: To introduce fundamentals of groundwater hydrology, groundwater assessment and groundwater development.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Definition of groundwater, role of groundwater in hydrological cycle, groundwater bearing formations, classification of aquifers, flow and storage characteristics of aquifers, Darcy's law, anisotropy and heterogeneity.	5
2.	**Governing Equations for Groundwater Flow:** Dupuit-Forchheimer assumptions, general differential equations governing groundwater flows, analytical solutions.	6
3.	**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, method of images, pumping test analysis.	8
4.	**Groundwater Conservation:** Regional groundwater budget; resource assessment; estimation of recharge, Indian practice, artificial recharge	5
5.	**Groundwater Quality:** General problem of contamination of groundwater, sources, remedial and preventive measures, seawater intrusion in coastal aquifers.	6
6.	**Groundwater Flow Modelling:** Role of groundwater flow models, reference to hydraulic, Hele-Shaw and analog models, introduction to numerical modeling.	6
7.	**Planning of Groundwater Development:** constraints on the development, role of flow models, optimal groundwater development.	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication/ Reprint
1.	Bear, J., "Hydraulics of Ground Water", McGraw.	1979
2.	Walton, W.C., "Ground Water Resources Evaluation", McGraw Hill.	1970
3.	Freeze and Cherry, "Ground Water", Prentice Hall.	1979
4.	Driscoll, F.G., "Ground Water and Wells", Johnson Division.	1986
5.	Raghunath, H. M., "Ground Water", New Age International (P) Limited.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE : **Department of Civil Engineering**

1. Subject Code : **CEN-631** Course Title : **Fluvial Hydraulics**
2. Contact Hours : **L: 3** **T : 1** **P: 0**
3. Examination Duration (Hrs) : **Theory : 3** **Practical : 0**
4. Relative Weight : **CWS : 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits : **4** 6. Semester: **Spring** 7. Subject Area : **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the flow characteristics in an alluvial channel with erodible boundary.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	The sediment problems, properties of sediments, incipient motion of uniform and non-uniform sediments.	8
2.	Bed forms and channel resistance.	5
3.	Bed load and suspended load transport for uniform and non-uniform bed material, total load equations, sediment sampling.	10
4.	Stable channel design and sediment control.	4
5.	Bed level variations, local scour, degradation, aggradation and reservoir sedimentation.	7
6.	Physical and mathematical models.	4
7.	Design of guide bunds and other river training banks.	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/ Publisher	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., “Principals 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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE : **Department of Civil Engineering**

1. Subject Code : **CEN-632** Course Title : **Hydraulic Structures**
2. Contact Hours : **L: 3** **T : 1** **P: 0**
3. Examination Duration (Hrs) : **Theory : 3** **Practical : 0**
4. Relative Weight : **CWS : 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits : **4** 6. Semester: **Spring** 7. Subject Area : **PEC**
8. Pre-requisite: **Nil**

9. Objective: To introduce various hydraulic structures and their hydraulic design.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Hydraulic structures for water resources projects.	2
2.	Embankment Dams: Types, design considerations, seepage analysis and control, stability analysis, construction techniques.	8
3.	Gravity Dams: Forces acting on failure of a gravity dam, stress analysis, elementary profile, design of gravity dam, other functional features of a gravity dam.	8
4.	Dam Outlet Works: Types of outlet structures, ogee spillway, chute spillway, siphon spillway, side channel spillway, Labyrinth and Pianokey weir.	8
5.	Terminal Structures: Hydraulic jump types, stilling basin, roller bucket, ski jump basin, baffled spillway, drop structure	7
6.	Hydraulic Modeling: Basic principles, dimensional analysis, modeling free-surface flows, design of physical models	9
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication/ Reprint
1.	Peterka, A.J, “Hydraulic Design of Stilling Basins and Energy Dissipators”, USBR Engineering Monographs No. 25”.	1984
2.	"Design of Small Dams", Third Edition, Water Resources Technical Publication – US Bureau of Reclamation.	1987
3.	Singh, B., and Varshney, R.S., "Embankment Dam and Engineering", Nem Chand and Brothers.	2004
4.	Chanson, H., “The Hydraulics of Open Channel Flow : An Introduction”, Elsevier Scientific Publications.	2004
5.	Novak, P. and Nalluri, C., “Hydraulic Structures”, Edition 4, Taylor & Francis.	2007
6.	Creager, Justin and Hinds, “Engineering for Dams”, Vol. I and II, John Wiley.	

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE : **Department of Civil Engineering**

1. Subject Code : **CEN-633** Course Title : **Systems Engineering**
2. Contact Hours : **L: 3** **T : 1** **P: 0**
3. Examination Duration (Hrs) : **Theory : 3** **Practical : 0**
4. Relative Weight : **CWS : 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits : **4** 6. Semester: **Spring** 7. Subject Area : **PEC**
8. Pre-requisite: **Nil**

9. Objective: To introduce basic concepts of systems, system modeling, system synthesis and optimization.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Definitions and components of a system, system control, systems modelling and model development.	10
2.	System synthesis. economic analysis, conflicts and role of optimization in their resolution.	6
3.	Unconstrained optimization – analytical and numerical.	3
4.	Constrained optimization – analytical and numerical.	3
5.	Integer programming.	2
6.	Geometric programming.	2
7.	Linear programming.	10
8.	Dynamic programming.	3
9.	Stochastic programming.	3
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication/ Reprint
1.	Aguilera, R.J., "Systems Analysis and Design", Prentice Hall.	1973
2.	Ossenbruggen, P. J., "Systems Analysis for Civil Engineering", John Wiley.	1984
3.	de Neufrille, R., "Systems Analysis for Engineer" , McGraw Hill.	1971
4.	Rao, S.S., "Engineering Optimization – Theory and Practice", New Age International (P) Ltd.	1999
5.	Hamdy, A.T., "Operations Research – An Introduction", Prentice Hall.	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE : **Department of Civil Engineering**

1. Subject Code : **CEN-634** Course Title : **Water Resources Systems Planning**
2. Contact Hours : **L: 3** **T : 1** **P: 0**
3. Examination Duration (Hrs) : **Theory : 3** **Practical : 0**
4. Relative Weight : **CWS : 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits : **4** 6. Semester: **Spring** 7. Subject Area : **PEC**
8. Pre-requisite: **Nil**

9. Objective: To introduce various aspects of systemic water resource planning and the relevant mathematical tools.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Water resources planning process, multi-objective planning.	3
2.	**Evaluation of Water Plans:** Basic concepts of engineering economics, welfare economics, economic comparison of alternatives.	4
3.	**Water Plan Optimization:** Plan formulation, objective functions and constraint, analytical optimization, numerical optimization, linear programming, dynamic programming, simulation, planning under uncertainty.	10
4.	**Deterministic River Basin Modeling:** Stream flow modeling, estimation of reservoir storage requirements – dead storage, active storage for water supply/ irrigation / power generation, flood storage, optimal allocation.	10
5.	**Conjunctive Use/Groundwater Management Models:** LP based conjunctive use modeling, aquifer response models, link - simulation, embedded, matrix response based models, soft modeling.	10
6.	**Water Quality Management Models:** Basic water quality modeling, objectives of management, control alternatives, optimal plans.	5
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/Publisher	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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE : **Department of Civil Engineering**

1. Subject Code : **CEN-635** Course Title : **Irrigation and Drainage**
2. Contact Hours : **L: 3** **T : 1** **P: 0**
3. Examination Duration (Hrs) : **Theory : 3** **Practical : 0**
4. Relative Weight : **CWS : 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits : **4** 6. Semester: **Spring** 7. Subject Area : **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce concepts of irrigation engineering including drainage and salt balance / leaching aspects.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction, objectives of irrigation, type of irrigation and suitability; selection of irrigation method.	3
2.	Irrigation requirement, water balance, soil water relationships, water storage zone, infiltration.	6
3.	Flow of moisture through root zone, soil physical and chemical properties, crop evaporative and drainage requirements, irrigation efficiency and uniformity.	4
4.	Surface irrigation systems, types of surface systems, basin irrigation, border irrigation, furrow irrigation, field measurement techniques, flow measurement, flumes, weirs, irrigation events, advance, wetting, depletion and recession phases.	7
5.	Infiltration, infiltrometer, ponding methods, soil water, tensiometers, neutron probe, time domain reflectometer, evapotranspiration, crop coefficient, leaf area index, FAO guide lines on evapotranspiration estimation.	6
6.	Fundamentals of surface irrigation hydraulics, continuity equation, momentum equation	3
7.	Hydrodynamic model, zero inertia model, kinematic wave model.	4
8.	Drainage principles, need for drainage, steady state equations, Hooghoudt, Kirkham, Dagan and Ernst equations.	6
9.	Salt balance, water and salt balance of the root zone, salt equilibrium equation and leaching requirement, leaching efficiency.	3
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/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
5.	Majumdar, D.K., “Irrigation Water Management”, PHI Learning.	2009
6.	Luthin, J.N., "Drainage Engineering", John Wiley.	1966

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE : **Department of Civil Engineering**

1. Subject Code : **CEN-636** Course Title : **Hydro Power Engineering**
2. Contact Hours : **L: 3** **T : 1** **P: 0**
3. Examination Duration (Hrs) : **Theory : 3** **Practical : 0**
4. Relative Weight : **CWS : 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits : **4** 6. Semester: **Spring** 7. Subject Area : **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce fundamentals of hydropower, transient analysis and various components of a hydropower plant.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Water Power:** Introduction, sources of energy, role of hydropower in a power system.	3
2.	**Estimation of Water Power Potential:** Flow duration curves of gauge and ungauge streams, load curve, load factor, capacity factor, utilization factor, diversity factor, load duration curve, firm power, secondary power, prediction of load.	7
3.	**Types of Hydro-power Plants:** Run of river plants, general arrangement of run of river plants, valley dam plants, diversion canal plants, high head diversion plants, storage and pondage, pumped storage power plants.	4
4.	**Penstocks:** General classification, design criteria, economical diameter, losses, anchor blocks, valves, bends and manifolds.	6
5.	**Trash racks:** Types, losses, design, stability.	4
6.	**Intakes:** Types, losses, air entrainment, anti-vortex device, air vent, power channels, forebay, tunnel.	6
7.	**Turbines:** Introduction, types of turbines, hydraulics of turbines, velocity triangles, draft tubes, cavitation in turbines, turbine model testing, characteristics of turbines.	6
8.	**Water Hammer and Surges:** Introduction, water hammer, transients caused by turbine, load acceptance and rejection, resonance in penstocks, surge tanks, channel surges.	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/ Reprint
1.	Dandekar, M.M., and Sharma, K.H., "Water Power Engineering", Vikas Publishing House Pvt. Ltd.	2000
2.	Barrows, H.K., "Water Power Engineering", Tata McGraw Hill Publishing Company Ltd.	1943
3.	Varshney, R.S., "Hydro Power Structures", Nem Chand & Bros.	2001
4.	Nigam, P.S., "Hydro Electric Engineering", Nem Chand & Bros.	2001
5.	Choudhary, M.H., "Applied Hydraulic Transients", Van Nostrand Reinhold Company	1987
6.	Streeter, V.L., and Wylie, B., "Fluid Transients", McGraw-Hill Book Company.	1967
7.	Warnick, C.C., "Hydropower Engineering", Prentice-Hall.	1984
8.	Norwegian Institute of Technology: Hydropower Development: Vols. 3, 4, 5 & 6, Division of Hydraulic Engineering.	1992-93

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE : **Department of Civil Engineering**

1. Subject Code : **CEN-637** Course Title : **Computational Methods in Fluid Mechanics**
2. Contact Hours : **L: 3** **T : 1** **P: 0**
3. Examination Duration (Hrs) : **Theory : 3** **Practical : 0**
4. Relative Weight : **CWS : 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits : **4** 6. Semester: **Spring** 7. Subject Area : **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce various numerical techniques and their applications to transient pipe flow, open channel flow and groundwater flow and contaminant transport.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Review of numerical techniques like method of characteristics, finite difference method.	7
2.	Finite element method.	6
3.	Modelling of steady state flow and hydraulic transients in pipes.	6
4.	Modelling of non-uniform, transient spatially varied flows in open channels.	7
5.	Numerical solutions for Navier-Stokes, boundary layer and Reynolds equations.	8
6.	Modelling of groundwater flow and contaminant transport in groundwater.	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/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
5.	Streeter and Wylie, "Fluid Transients", McGraw Hill.	1976
6.	Smith, G.D., "Numerical Solution of Partial Differential Equations-FDM".	1985