HYDRAULIC STRUCTURES

I – Semester

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE 611	Design of Irrigation Works	4	3	0	1

Unit 1 Hydraulic structures on permeable foundation, Failure of hydraulic structures founded on permeable soil, Design of barrage, Design of guide bund, Design of spurs

Unit 2 Design of subcritical canal transitions: Hind' method, Vittal and Chiranjeevi' s method of transition design, Design of supercritical transition

Unit 3 Design of head and cross regulators

Unit 4 Design of flumed glacis fall, Design of silt excluder and silt

Text Books and Reference Materials

1. P.N. Modi, "Irrigation Water Resources and Water Power"
2. Bharat Singh, "Irrigation Engineering"
3. S. K., "Garg Irrigation Engg. and Hydraulic Structures"
4. Varshney and Gupta Irrigation Engg.

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE 612	Reservoir Engineering	4	3	0	1

Unit 1

Reservoirs: Types, Site selection, site Investigations, physical characteristics, Determination of elevation-area and elevation capacity curves, various zones of reservoir

Unit 2

Selection of capacity of reservoir for constant and variable demand, Flow mass curve, Arithmetic method, Sequent Peak Algorithm, Allocation of storage space in a reservoir: Criteria of fixation of storage space for various purposes

Unit 3

Reservoir Sedimentation: Mechanics of sedimentation, Estimation of silt load-sampling method and empirical formula, life of a reservoir, distribution of sediment in a reservoir

Unit 4

Peak flood estimation, Flood routing, Reservoir operation, Probability concepts in reservoir planning and design, Concept of Risk, Reliability and safety factor for a Reservoir.

Text Books and Reference Materials

1.. Varshney, R.S. (1979) , Engineering Hydrology, Nem Chand & Bros., Roorkee, India

2. Subramanya, K. (1984), Engineering Hydrology, Tata-McGraw-Hill Publishing Company , India.

3. Reddy, Hydrology, Laxmi Publication (P) LTD , India.

4. SahasraBudhe, S.R.(1994), Irrigation Engineering & Hydraulic Structures, S.K. Kataria &Sons, India.

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE 613	Fluvial Hydraulics	4	3	0	1

Unit 1 Importance of Fluvial hydraulics in civil engineering problems, Sediment properties: bulk properties and properties of a single sedimentary particle, Hydraulics of alluvial channels

Unit 2 Initiation of sediment motion, resistance of flow, regimes of flow in alluvial channels, Bed forms

Unit 3 Bed load, suspended load and total bed material load equations, Velocity distribution in alluvial streams, Sediment sampling

Unit 4 Design of stable channels in alluvium, River models, Sediment flow through pipes

Text Books and Reference Materials

1. Mechanics of sediment transport through alluvial Channesl R.J. garde and ranga Raju

Publisher: New Age publications

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE 614	Rigid Dams	4	3	0	1

Unit 1 Dam: types, characteristics, Relative merits and demerits, Site investigations and selections, preparation and treatment of the foundation grouting. Forces acting on dam.

Gravity dams **:** Stability requirements, modes of failure and factor of safety, methods of analysis instrumentation in concrete gravity dam. Design criteria

Unit 2 Elementary profile of gravity dam. Stress analysis in Gravity dams, Normal and shear stresses, Principal stresses, Internal stresses, Zoning of gravity dams, galleries in dams, stress concentration around openings, joints in dams, construction of gravity dams.

Unit 3 Arch Dam : General consideration, types and characteristics, Forces acting on Arch dams, Design criteria, Cylinder theory and elastic theory of design, Construction of arch dams.

Unit 4 Buttress dam : Merits, Types and characteristics, Forces acting, design of deck,

buttresses, Unit column theory, Construction of buttress dam.

Text Books and Reference Materials

1. R.S. Varshney "Concrete Dams", by 1982, NCB, Roorkee
2. Design of Small Dams, USBR 1960, Calcutta, Oxford and IBH
3. W.P. Creager, J. Justin,.Daud Hinds, "Engineering for Dams" Vol. I-III, Wiley, N.Y., USA.
4. IS: 6512-1984, Criteria for Design of solid Gravity Dams.
5. IS:1893-1984, , Criteria for Earthquake resistant Design of structures.

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE 615	Earth and Rockfill Dams	DC	3	0	1

Unit 1

Basic design aspects, Classification of embankment dams, Criteria for safe design, Typical sections, Free board, Upstream and downstream slope protection, Cracking of earth dams, Hydraulic fracturing, Causes of cracking, Preventive and remedial measures

Unit 2

Seepage theory, Determination of free surface and discharge through dam, Anisotropic seepage, Flow net for earth dam under steady seepage condition, Methods of seepage control, Selection of core materials, Drainage of embankments, Design of transition filters, Use of geo-textiles as filter material

Unit 3

General characteristics of Rock fill dams, Materials for rock fill dams, Design of dam section, Types of membrane, Rock fill placement, Deformation of rock fill dams

Unit 4

Stability analysis, Method of slices, Graphical method, Foundation exploration for Earth and Rock fill dams, Treatment of foundations, Quality control and instrumentation

Text Books and Reference Materials

1. **Hind, Creager and Justin**, Engineering for dams, Wiley, 1967.
2. **Bharat Singh**, Embankment Dam Engineering, Nem chand & Bros Roorkee.
3. **Sowers G**. I. Earth and Rockfill Dam engineering, A. Earth Manual, USBR Publication.

4. **Sharma** H. D., Embankment Dams, Oxford and IBH Pub., 1991.
5. **Design of Small Dams**, USDI, Oxford and IBH, 1976

II Semester

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-616	**Advanced Engineering Hydrology**		3	0	1

Unit 1 Design Storms, Probable Maximum Precipitation, Spillway design flood, Standard project flood, Probable maximum flood. Guide lines for selecting design flood. Separation of Stream Flow Components

Unit 2 Statistical and Probability Analysis of Hydrologic Data, Probability and Stochastic methods of Flood Frequency analysis, Regression analysis and Correlation

Unit 3 Regional Flood Frequency Analysis, Risk, Reliability and Safety Factor, Flood Routing Mathematical models in hydrology.

Unit 4 Concept of hydrograph, Hydrograph analysis, Derivation of Unit Hydrograph, Synthetic Unit Hydrograph, Instantaneous unit hydrograph, Dimensionless unit hydrograph, Distribution graph.

Text Books and Reference Materials

1. K. Subramanya, “Engineering Hydrology”, TMH, New Delhi, India.
2. Chow V.T, “Hand book of Applied Hydrology”, Mc Graw-Hill, N.Y., USA.
3. J. Nemec, “Engineering Hydrology”, Mc Graw-Hill, N.Y.
4. Linsley, Kohler and Paulhus, “Applied Hydrology”, Mc Graw Hill, N.Y., USA.
5. D.K Todd, “Groundwater Hydrology”, John Wiley, N.Y., India

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-617	**Water Power Engineering**	4	3	0	1

Unit 1

Introduction, Water power development, Power potential of stream, Load prediction,

Basic terminology related to hydro plants, Hydro-power plants, classification, elements.

Unit 2

Intakes, Classification, Losses in intakes, tunnels, Classificatiom and Lining of tunnels and Draft Tubes, classification, design, efficiency of draft tubes.

Unit 3

Penstocks, classification, design criteria, economical diameter of penstock,Water hammer

analysis, surge tanks, classification and their hydraulic design.

Unit 4

Turbines, their selection and number of units, setting of turbines, Power house , superstructure and substructures, layout and dimensioning of hydro power house,

Safety and environment issues in water resources projects

Text Books and Reference Materials

1. Hydro Power Engineering, by Dandekar and Sharma,
2. Hydro Power Structures by Varshney NCB, Roorkee, India
3. Water Hammer by Permakian
4. Analysis of Surge by Pickford
5. Water Power Engineering by Barrows
6. Hydro-electric Handbook Creger and Justice
7. Construction site safety byRichard Hislap
8. Risk in Civil Engineering from Natural and Manmade Hazards byPierre Dilage.

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-618	**Advanced Hydraulics**	4	3	0	1

Unit 1

Gradually Varied Flow: Computation of GVF profiles using analytical and numerical methods Unsteady Flow: St. Venant's equations and their solution, hydraulic flood routing, Dam break problem.

Unit 2

Rapidly Varied flow:thin plate weirs, special types of weirs such aslinear proportional weir, Labyrinth weir, Piano key weir. Hydraulic jump in non-rectangular channels,

Unit 3

Spatially Varied Flow: Side channel spillway, side weir, De Marchi equation, uniformly discharging side weir, Trench weir.

Unit 4

Air-entrainment in spillways and hydraulic jumps, Diffusion and Dispersion, Governing Equations, some classical solutions of diffusion equation, Dispersion and diffusion coefficients

Text Books and Reference Materials

Flow in open channel	K. Subramanya
Flow through open channels	K G RangaRaju
Flow through open channels	Rajesh Srivastava
Open Channel Flow	M HanifChaudhry
Open Channel Hydraulics	VenTe Chow

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
AM-611	**Higher Mathematics**		3	0	1

Unit 1
Optimization: Formulation of linear programming problem, Simplex methods, Introduction to non-linear programming.

Unit 2

Probability and random variables , PDF, CDF, Moments and Expectation,Distribution Functions, Normal, Lognormal, Introduction to estimation ,method, Regression Analysis; linear and non-linear, correlation.

Unit 3
Probability, sample space, events. Solution of simple problems using laws of Probability. Conditional probability, Dependent and Independent events. Addition and Multiplication theorems of Probability

Unit 4
Reliability of statistical analysis, standard error, confidence limits, Analytical method of testing the goodness of fit for the probability function to empirical distribution, Degree of freedom, Chi-square test.

Text Books and Reference Materials

1. **Taha**, H.Y.A., Operation Research, Prentice _Hall of India, Private Limited, New Delhi.
2. **Varshney**, R.S. (1979) , Engineering Hydrology, Nem Chand & Bros., Roorkee, India.
3. Meyer, Programing and Statistics.
4. **Meyer**, P.L., Introduction Programing & Statistical Application, Oxford & IBH Publication Co., Private Limited, New Delhi.

III Semester

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE- 711	Spillway and Energy Dissipators		3	0	1

Unit 1
Theory of Spillways**:** Introduction, Ogee spillway, Side channel spillway, Chute spillway, Shaft spillway, Siphon spillway: volute siphon and saddle siphon, Location of spillway.
Unit 2
Design of Spillways**:** Introduction, Stability, Performance, Design of upstream profile of spillway, Design of downstream profile of spillway.
Unit 3
Intake works and Gates**:** Introduction, Sluiceways or dam outlet, Hydraulics of outlet works, River intakes: Simple submerged intakes, Intake towers, wet intake and dry intake, Trash Racks. Dropping shutters, stop logs and needles, Vertical lift gates, Radial or tainter gates, Drum gate, Intake gates and valves.
Unit 4
Energy Dissipaters**:** Energy dissipation below overflow spillways, Hydraulic jump, Jump height curve and Tail water curve, Stilling basins,Chute blocks, Sills and dented sills, Baffle piers, U.S.B.R. Basins.

Text Books and Reference Materials

1. Theory and Design of Irrigation Structures Vol I by R S Varshney and S C Gupta.
2. Theory and Design of Irrigation Structures Vol II Canal and Storage Works by R S Varshney.
3. . Irrigation and Water Power Engineering by Dr. B.C. Punmia, Ashok Kumar Jain and Arun Kumar Jain.
4. Irrigation Engineering and Hydraulic structures by SK GARG.

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-791 H	Lab Project	4	3	0	1

(a) Experiments:

1. Comparative study on Loss coefficients due to a sudden expansion, contraction, different types of bend with flow parameters in a pipe.
2. Demonstration of scour process at bridge pier in a tutor flume.
3. Scour process due to a Jet in a transparent tank
4. Effect of various flow parameters on Manning's roughness coefficient 'n'.
5. Investigate the Characteristics of runoff hydrograph in a Hydrologic modeling tank
6. Experimental Study of Hydraulic Jump characteristics in a rectangular Channel.

(b) Projects:

Analysis and design of selected hydraulic structures / structural elements / models

Text Books and Reference Materials

1. White, F. M. "Fluid Mechanics", Mc Graw-Hill, New Delhi, India.
2. Garde, R. J. " Fluid Mechanics ", RPH, Roorkee, India.
3. Chow, V.T. "Hand book of Applied Hydrology", Mc Graw-Hill, N.Y., USA.
4. Asawa, G. L. " Laboratory work in Hydraulic Engineering", New Age International Publishers, India.
5. Ranga Raju, K.G. " Flow through open channe", Tata Mc Graw-Hill, New Delhi, India
6. Subramanya, K. " Flow in open channels", Tata Mc Graw-Hill, New Delhi, India

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE- 780H	General Seminar	4	3	0	1
Topics related to general interest of Hydraulic and Water resources Engineering such as Rain water Harvesting, Scour and Erosion, Flow measuring devices, Hydro-power structures, Sources of Energy in nature etc.					

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE- 781H	Prelim Dissertation Seminar	4	3	0	1
Any suitable research topic relevant to Hydraulic and Water Resources Engineering from the following thrust areas such as: Local scour around hydraulic structures, Sediment controlling measures, Rainfall run-off analysis, Reliability based design of various hydraulic structures, Seepage flow through porous media, Water Management, Sources of Energy, Application of New mathematical techniques such as ANN, Genetic Algorithm etc in various water resources problems.					

Course No.	Course Title	Course Type	Credits	Contact Hours		
				L	P	G
CE 782H	Final Dissertation Seminar	DC	2	0	2	0

Any suitable research topic relevant to Hydraulic and Water Resources Engineering from the following thrust areas such as:

Local scour around hydraulic structures, Sediment controlling measures, Rainfall run-off analysis, Reliability based design of various hydraulic structures, Seepage flow through porous media, Water Management, Sources of Energy, Application of New mathematical techniques such as ANN, Genetic Algorithm etc in various water resources problems.

Course No.	Course Title	Course Type	Credits	Contact Hours		
				L	P	G
CE 798H	Dissertation	DC	2	0	2	0

Any suitable research topic relevant to Hydraulic and Water Resources Engineering from the following thrust areas such as:

Local scour around hydraulic structures, Sediment controlling measures, Rainfall run-off analysis, Reliability based design of various hydraulic structures, Seepage flow through porous media, Water Management, Sources of Energy, Application of New mathematical techniques such as ANN, Genetic Algorithm etc in various water resources problems.

Electives

Course No.	Course Title	Course Type	Credits	Contact Hours		
				L	P	G
CE 601	Higher Numerical Analysis	DC	4	3	0	1

Unit 1

Types of errors, General formula for errors, order of approximation. Nonlinear equations: Classification of Methods, Approximate values of roots, Bisection Method, RegulaFalsi Method, Newton Raphson Method, Fixed Point iteration, Mullers Method. Use built in functions in MATLAB software to solve problems.

Unit 2

Linear Systems of Equations: Direct Method - Matrix Inversion Method, Gauss Elimination Method, Gauss Jordan Elimination Method, Cholesky Method.

Iterative Methods- Jacobi Iteration Method, Gauss Seidel Method. Eigen value problem. Use built in functions in MATLAB software to solve problems.Interpolation and Approximation: Lagrange and Newton Interpolation, Finite difference operators.Use built in functions in MATLAB software to solve problems.

Unit 3

Numerical solution of Ordinary: Introduction, solution by Taylor's series, Picards method of successive approximations, Euler's method: Error estimates for the Euler method, modified Euler's method, Runge-Kutta methods, simultaneous and higher order equations using Taylor's series, Picards method of successive approximations, Euler's method, Boundary Value Problems: Finite Difference method.

Unit 4

Numerical solution of Partial Differential Equations: Introduction, Finite Difference Approximation to derivatives, Laplace's, Parabolic Equations and Hyperbolic Equation: Jacobi's method, Gauss Seidel method, Iterative methods for the solution of equations, Variational and weighted residual methods, Introduction of FEM.

Text Books and Reference Materials

1. Numerical Analysis: Goel & Mittal
2. Applied Numerical Analysis: Gerald & Wheatley
3. Numerical Methods for Engineers: Chapra & Canale
4. Introductory Methods of Numerical Analysis: Sastry, Numerical Methods: Jain and Jain

Course No.	Course Title	Course Type	Credits	Contact Hours		
				L	P	G
CE625	Air Pollution and Control	DC	4	3	0	1

Unit 1

Classification, Sources and Effects of air pollutants, Sampling Methods and Measurements of Air Pollutants, Measurement and analyses of primary air pollutants SO_2, NO_x and SPM using high volume sampler, Ambient Air Quality Standards, Emission Standards.

Unit 2

Basic Meteorology, Transport, Dispersion and Transformation of pollutants in Air, Adiabatic Lapse Rate, Atmospheric Stability, Dispersion of Pollutants,Air Pollution Dispersion Models, Point, Line and Area Source Models, Inversions, Plume Behaviour, Mixing Height, Plume Rise, Stack Emissions and Design.

Unit 3

Air Pollution Control Techniques, Control of Particulate Matter, Theory and description of control devices and their applications, Equipments and their Design, Selection of Control Equipments, Engineering Control ConceptsGravity Settling Chamber, Cyclone, Fabric Filter, Electrostatic Precipitator.

Unit 4

Control of Gaseous Pollutants-Oxides of Nitrogen and Sulphur, Sources and effects of noise pollution, Kinetics of noise, Measurement and control of noise pollution, Climate Change, Odour Removal, Atmospheric Chemistry, Photochemical Smog, Global Change-Greenhouse Effect and Global Warming, Ozone Layer Depletion, Acid Rain, Air Emissions from Wastewater Treatment Facilities and their Control.

Text Books and Reference Materials

1. Rao M.N. and Rao H.V. N, Air Pollution, Tata Mc-Graw Hill Publishing Co. New Delhi, Third Edition, 1992.
2. Y. Anjaneyulu, A textbook of air pollution & control technology, Allied publishers.
3. Nevers N.D, Air Pollution control Engineering, Editions Civil Engineering series, 1995.
4. Rao C.S., Environmental Pollution Control Engg, New Age International Pvt. Ltd. Publishers, 2006.
5. Stern A. C, Air pollution, Tata McGraw Hill International, Vol I to IX Winter, G. “Design of Concrete Structures” McGraw Hill, Tokyo, Japan.

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE- 661	**Flow Through Porous Media**	4	3	0	1

Unit 1 Linear and non-linear seepage through porous media, Equations of motion, Seepage model, Kozney and Carmon equation

Unit 2 Steady state seepage, Unconfined aquifers: with positive and negative recharge, Leaky artesian aquifers, one and two layered systems, Aquifers with inclined impervious boundary

Unit 3 Types of wells, Partially penetrating wells, Non-equilibrium seepage, Determination of aquifer constants, Sea water intrusion in costal aquifers

Unit 4 Porous media models: Hydraulic radius model, Viscous drag model, Fissured rock model, Unit cell model, Capillary model and Statistical models.

Text Books and Reference Materials

1. Scheidegger, A.E." The Physics of Flow Through Porous Media", University of Toronto Press.
2. Raghunath, H, M. " Ground Water ", New Age International, India.
3. Linsley, Kohler and Paulhus, “Applied Hydrology”, Mc Graw Hill, N.Y., USA.
4. Todd, D.K “Groundwater Hydrology”, John Wiley, N.Y., India.
5. Linsley, Franzini, “Water Resources Engineering”, Mc Graw Hill, N.Y., USA

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-662	**Water Resources Engineering**	4	3	0	1

Unit 1

Planning for water resources developments, Levels of planning, Phases, Objectives, Data requirements, Project formulation and Evaluation, Environmental considerations, Functional requirements in Multiple-purpose projects

Unit 2

Engineering economy in water resources planning, Annual cost comparisons, Selection of an interest rate for an economy study, Economic design of hydraulic structures

Unit 3

Flood damage mitigation, Design floods, Flood mitigation reservoirs, Design of levees and flood walls, Flood ways, Channel improvement, Evacuation and flood proofing. Land management and flood mitigation, Flood-plain management

Unit 4

Simplified river-basin system, Conventional planning process, Simulation analysis, Mathematical models

Text Books and Reference Materials

1. **Linsley, Franzini & Freyberg**, Water Resources Engineering, McGraw Hill 1992.
2. **Patra** KC, Hydrology and water resources Engineering, Narosa publishing House, Second Edition, 2008
3. **Raghunath**,H.M.,Hydrology,New Age Publishers, New Delhi

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-663	**Experimental Methods in Fluids**	4	3	0	1

Unit 1
Introduction to Instruments and their representation, Selection of Instruments, Lasers, Cameras, and optics, Particle image velocimetry (PIV), Application of PIV, Variations of the PIV technique

Unit 2
Introduction to Force,Pressure, Temperature and Discharge Measurements, Laser Induced Fluorescence

Unit 3
Basic statistical concepts, Normal Distribution, Test of outlier, Reliability of Statistical Analysis, Chi-square test

Unit 4
Graphical Representation and curve fitting of data, Covariance, correlation and regression, Linear regression, Multiple regression, Application of regression technique.

Text Books and Reference Materials

1. Fluid Mechanics Measurements, R. J. Goldstein, 2nd Ed. 1996, Taylor & Francis.
2. Theory and Design of Mechanical Measurements,Figliola& Beasley, 3rd Ed., 2000, Wiley
3. Particle image Velocimetry: A Practical Guide,"MarkusRaffel, Christian E. Willert, JurgenKompenhans, 1998, Springer-Verlag
4. Fluid Mechanics,"Frank M White, 5th Ed., 2003, McGraw-Hill

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-664	**Hydrogeology and Ground Water Modeling**	4	3	0	1

Unit 1 Porosity, Permeability and Related Parameters, Grain Size Analysis. Darcy's law. Origin and age of ground water. Ground water utilization & historical background, Ground water in hydrologic cycle.

Unit 2 Confined, Homogeneous and Heterogeneous Aquifer, Confined one dimensional steady state Flow in aquifer. Confined one dimensional Flow in Aquifer with varying thickness. Aquifer with and without infiltration, confined non-leaky Aquifers.

Unit 3 Sudden change at the Boundary, Hydro-geological Parameters, Streamlines & flow nets. Water walls steady static flow. Concept and methods of artificial ground water recharge. Waste water recharge for use.

Unit 4 Group of wells, wells near boundaries, Three step modeling concept. Time series modeling, numerical ground water flow modeling, calibrated models, Porous media models, Pumping Tests.

Text Books and Reference Materials

1. D. K. Todd and L. F. Mays, "Groundwater Hydrology", John Wiley, N.Y. USA.
2. K. R. Karanth, "Hydrogeology", TataMcGraw Hill Publishing Company, New Delhi, India.
3. K. Subramanya, "Engineering Hydrology", TMH, New Delhi, India.
4. Chow V.T, "Hand book of Applied Hydrology", Mc Graw-Hill, N.Y., USA

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
AM-612	**Computational Fluid Dynamics**	4	3	0	1

Unit 1

Potential flow: Rectilinear flow. Sources and sinks. Superposition principle, Source in rectilinear flow, Doublets in rectilinear flow with circulation

Unit 2

Numerical Solution of system of equations: Nonlinear equations by Newton-Raphson and general iterative methods. Numerical solution of a system of differential equations by Runge-Kutta methods of order two and four.

Unit 3

Finite difference Approximations, Explicit and implicit finite difference scheme, boundary conditions, stability, diffusive scheme, Solution of Partial differential equations with stability.

Unit 4

Finite Element Method, Domain discretization, Method of weighted residual, collocation, Galarkin and Raleigh-Ritz methods.

Text Books and Reference Materials

1. Jain, A.K., Fluid Mechanics, Khanna, Publisher, New Delhi
2. Chaudhri, M.H, Open Channel Flow, Prentice-Hall of India
3. Reddy, J.N., Finite Element Method