राष्ट्रीय प्रौद्योगिकी संस्थान जमशेदपुर
NATIONAL INSTITUTE OF TECHNOLOGY JAMSHEDPUR
An Institution of National importance under MHRD, Government of India
Department of Civil Engineering

2018

CURRICULA AND SYLLABI

M.TECH (WATER RESOURCE ENGINEERING)

NIT,Jamshedpur

8/6/2018

PG PROGRAMME COURSE STRUCTURE

M.TECH (WATER RESOURCE ENGINEERING)

DEPARTMENT OF CIVIL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY JAMSHEDPUR

JAMSHEDPUR-831014, JHARKHAND

DEPARTMENT OF CIVIL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY JAMSHEDPUR
JAMSHEDPUR-831014, JHARKHAND, INDIA

COURSE STRUCTURE & DETAILED SYLLABI FOR M. TECH. (WATER RESOURCE ENGINEERING)

Sl. No.	Subject Code	Name of the Subject	L	T	P	C
		SEMESTER – I				
1.	CE4101	Advanced Numerical Analysis & Computer Programming	4	0	0	4
2.	CE4151	Applied Hydrology	4	0	0	4
3.	CE4152	Open Channel Hydraulics	4	0	0	4
4.		Elective-I	4	0	0	4
5.		Elective-II	4	0	0	4
6.	CE4163	Hydraulics and Water Resources Engineering Laboratory	0	0	2	1
		SEMESTER – II				
1.	CE4251	Computational Fluid Dynamics	4	0	0	4
2.	CE4252	Water Resources Systems Analysis	4	0	0	4
3.	CE4253	Water Resources Planning and Management	4	0	0	4
4.		Elective-III	4	0	0	4
5.		Elective-IV	4	0	0	4
6.	CE4262	Computational Laboratory	0	0	2	1
		SEMESTER – III & IV				
1.	CE4351	Seminar	0	0	4	4
2.	CE4352	Dissertation Module - I (continued in next Semester)				16
3.	CE4451	Dissertation Module - II (continued from III Semester)				20

Total Credits: 82

Elective – I, II

Sl. No.	Subject Code	Name of the Subject	L	T	P	C
1.	CE4153	Water Supply Systems	4	0	0	4
2.	CE4154	Remote Sensing and GIS Applications in Land and Water Resources	4	0	0	4
3.	CE4155	Flood Estimation and Control	4	0	0	4
4.	CE4156	Groundwater Resources Development and Management	4	0	0	4
5.	CE4157	Participatory Field Research Methodology	4	0	0	4
6.	CE4158	Watershed Conservation and Management	4	0	0	4
7.	CE4159	Urban Water Resources Management	4	0	0	4
8.	CE4160	Computational Intelligence for Hydro systems	4	0	0	4
9.	CE4161	Hydrologic Elements and Analysis	4	0	0	4
10.	CE4162	Stochastic Hydrology	4	0	0	4

Elective – III, IV

Sl. No.	Subject Code	Name of the Subject	L	T	P	C
1.	CE4201	Finite Element Method	4	0	0	4
2.	CE4254	Water Quality Modeling and Control	4	0	0	4
3.	CE4255	Design of Hydraulic Structures	4	0	0	4
4.	CE4256	Climate Change and Water Resources Modeling	4	0	0	4
5.	CE4257	Irrigation and Drainage Engineering	4	0	0	4
6.	CE4258	Environmental Impact Assessment of Water Resources Development	4	0	0	4
7.	CE4259	Embankment Dam Engineering	4	0	0	4
8.	CE4260	Groundwater Flow Through Porous Medium	4	0	0	4
9.	CE4261	Hydraulics of Sediment Transport	4	0	0	4
10.	CE4262	Hydropower Engineering	4	0	0	4

DETAILED SYLLABI OF COURSES

SEMESTER-I

Advanced Numerical Analysis & Computer Programming **CE4101**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Section A – Advanced Numerical Analysis

Solution of large Simultaneous equations [Cholesky's method], Iterative methods, Curve fitting, Numerical integration, Interpolation and Approximation, Solution of Non-linear equations, Newton's – Raphson method, Convergence and Divergence, Solution of Ordinary Differential equations and partial differential Equations, Euler method and Runga-Kutta method, Interpolation and Extrapolation, Finite Difference method, Eigen value problems, Initial and Boundary Value Problems, Variational and weighted residual methods, Introduction of Finite element methods.

Section – B Computer Programming

Introduction to the digital computer, FORTRAN 77/90/95 language/ (C/C++ Language), Flow charts and Computer program, Arithmetic and Assignments statements, Control statements, Do statements, Input/ Output Declarations, Comments type, dimension, equivalence, Data sub-programmes, Function and sub-routines, Simple computer programme or sub-routines for:

1. Inversion of a square symmetric matrix
2. Cholesky's method
3. Gauss-seidel iteration.
4. Solution of a non-linear equation by Newton-Raphson Method
5. Solution of Ordinary Differential equation by Rungakutta method.
6. Numerical differential.
7. Numerical Integration.

Text/ Reference Books:

1. Numerical Methods in Science and Engineering - S. Rajasekaran
2. Numerical Methods for Scientific and Engineering Computation - M. K. Jain, R. K. Iyengar and Jain
3. Numerical Mathematical Analysis - James B. Scarborough, Oxford and IBH Publishing.
4. Introductory Methods of Numerical Analysis - S. S. Sastry, PHI Learning (2012).
5. Numerical methods for Engineers - Chapra S. C. and Canale R. P., Tata Mc.Graw Hill Publishing
6. Applied Numerical Analysis - Gerald, Pearson Education, New Delhi, 2003
7. Numerical Algorithms - Krishnamurthy E. V. and Sen S. K. :, East- West Press Pvt Ltd., New Delhi.
8. Optimisation Theory and Applications - Rao S. S., Wiley Eastern Ltd., New York. 1979
9. An introduction to Numerical Analysis - Kendall Atkinson
10. Computational Engineering (Introduction to Numerical Methods) - Michael Schäfer
11. Computer Programmes in FORTARAN 90/95 – V. Rajaramana, PHI Pvt. Ltd., New Delhi

Applied Hydrology **CE4151**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Hydrologic Analysis: General Hydrologic system model; modelling protocol; linear and nonlinear systems; response functions of linear systems, unit hydrograph, synthetic unit hydrograph, and different theories of instantaneous unit hydrograph and parameter estimation techniques, flood routing.

Hydrologic statistics: Analysis of hydrologic data ; Flood frequency analysis, parameter estimation, commonly used distribution function in hydrology, concept of uncertainty and risk, Introduction to time series analysis and uncertainty analysis.

Hydrologic Design: Estimated Limiting Value, Hydrologic design scale and design level; Design storms – Design precipitation, IDF and DAD relationships, Design hyetograph, Estimated limiting storms and PMP; Flood plain analysis and flood control measures.

Text/ Reference Books:

1. Chow, V T., D. R. Maidment and L. W. Mays (1988), "Applied Hydrology", McGraw-Hill, Inc., New York.
2. Dingman L. S. (2002), "Physical Hydrology", 2nd Ed. Waveland Press, Inc., USA
3. Viessman, W. Jr. And G. L. Lewis (2003), Introduction to Hydrology, 5th Edition, Pearson
4. Education, Inc., New Jersey.
5. Hann C.T. (1995), "Statistical Methods in Hydrology", First East-West Press Edition, New Delhi.
6. Box, G. E. P., G. M. Jenkins, and G. C. Reinsel (2003), "Time Series Analysis, Forecasting and Control", Pearson Education, Singapore

Open Channel Hydraulics **CE4152**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Review of Fundamentals of Hydraulics, Introduction to open channel flow, basic features, uniform flow, critical flow, computing normal and critical depth, energy and momentum of flow, channel control and transitions, uniform flow and flow resistance, composite roughness and compound channels, gradually varied flow, classifications and computations of free surface profiles, spatially varied flow, supercritical flows and oblique flows, rapidly varied flow, hydraulic jump; Hydrometry – velocity measurements, discharge estimation methods and rating curve development methods ; Unsteady flow: Saint-Venant equation of continuity and momentum equations of motion, wave propagation and surge, method of characteristics, dam-break problem, flow in channel bends.

Text/ Reference Books:

1. Chow, V.T., Open Channel Hydraulics, McGraw-Hill, Tokyo, 1959.
2. Subramanya K., Flow in Open Channels, Tata McGraw-Hill, 1986.
3. Chaudhary, H., Open Channel Flow, Springer.
4. Mahmood, K. and Yevjevich, V., Unsteady flow in Open Channels, Water Resources Publications, Fort Collins, 1975.
5. RangaRaju, K.G., Flow through Open Channels
6. Henderson, open Channel Flow, Mac Millian series in Civil Engg. Inc.
7. Ralph A. Wurbs, Wesley P. James, Water Resources Engineering, Prentice-Hall of India Pvt. Ltd. New Delhi.

ELECTIVE – I, II

Water Supply Systems **CE4153**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Raw water Intake, screening, and aeration- types of intake structures, intake-site selection, intake design considerations, coarse screen or trash rack, fine screen, micro strainer, types of aeration and application of aeration.

Components of water distribution systems, Hydraulics of pipelines and pipe networks- basic equations for study flow, pumps in pipe lines-pump characteristics, pipeline with pump, culverts, pipelines connecting reservoirs- pipes in series, pipes in parallel, three reservoir system; pipe network systems- conservation laws, network equations, network simulations-Hardy Cross pipe network problem, linear method of pipe network analysis, branching pipe lines, municipal water distribution system, unsteady flow, generalized pipe system simulation models using EPANET software.

Hydraulic transients in distribution system- steady state flow in a pipe, water hammer condition, wave speed and pressure, control of hydraulic transients.

Text/ Reference Books:

1. Syed R. Qasim, Water Works Engineering, Ptrantice-Hall of India Pvt. Ltd., New Delhi, 2004.
2. Ralph A. Wurbs, Water Resources Engineering, Ptrantice-Hall of India Pvt. Ltd., New Delhi, 2002.
3. Larry W. Mays, Water Resources Engineering, John Wiley & Sons, Inc., 2001.

4. Gurucharan Singh, Water Supply and Sanitary Engineering, Standard Publishers Distributors, New Delhi.

Remote Sensing and GIS Applications in Land and Water Resources **CE4154**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Physics of remote sensing: Electromagnetic spectrum, atmospheric effects, energy interaction with earth surface features. Platforms and remote sensing sensors: Photographic camera, scanners, earth resources satellites, active and passive microwave sensors. Digital image processing: Image rectification, image enhancement, image classification and accuracy. Image interpretation. Geographical Information System (GIS): Map data representation, geographic database concepts and analysis. Application of remote sensing and GIS in land and water resources system and evaluation.

Text/ Reference Books:

1. Lillisand and Keefer, Remote Sensing and Image Interpretation, John Wiley & Sons, 1979.
2. Balakrishnan, P., Issues in Water Resources development and management; the Role of Remote sensing, Indian Space Research Organization (ISRO-NNRMS-TR-67-86), Bangalore, 1986.
3. Robert G. Reeves, et al., Manual of Remote Sensing, Volume I & II (American Society of Photogrammetry, Fall Church, 1975.

Flood Estimation and Control **CE4155**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Floods and its types, causes of floods, various methods of estimating floods, flood frequency analysis: assumptions, frequency analysis of annual and PoT series, deterministic methods, depth-area-duration curves, flood from small catchments, flood routing, detailed study of hydrological, kinematic, diffusion and hydraulic routing methods, two dimensional routing models, design flood estimation methods: Standard Project Flood and Probable Maximum Flood, Indian standard and CWC guidelines for design flood estimation for different structures, various methods of flood control including structural and non-structural measures such as embankments, diversion, floodplain zone flood forecasting and flood warning, flood fighting and urban floods single and multi-purpose projects, flood fighting, flood in urban areas

Text/ Reference Books:

1. Chow, V.T., (Ed), Handbook of Applied Hydrology, McGraw-Hill, 1964.
2. Linsley, Ray. K. and Franzini, Joseph. B., Water Resources Engineering, McGraw-Hill, 1972.
3. Chow. V.T., Maidment, D.R. and Mays, L.W., Applied Hydrology, McGraw-Hill, 1988.
4. Stephenson, D., Stormwater Hydrology and drainage, Elsevier Scientific Publishing Company, 1981.

Ground Water Resources Development and **CE4156**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Evaluation of groundwater resources- Investigation and evaluation, aquifer, types of aquifer, geology of aquifers, safe yield, factors governing safe yield, methods of computing safe yield. Hydrogeological systems analysis- analytical approach, model aquifers and mathematical models, physical models, numerical methods, finite difference methods. Groundwater management- optimization methods for groundwater management, groundwater supply models-allocation models, conjunctive use models. Groundwater recharge, sea water intrusion, land subsidence, wells in hard rock areas, groundwater law.

Text/ Reference Books:

1. Davis, S.N., and De Wiest, RJ.M., Hydrogeology, John Wiely and Son, Inc., New York, 1966.
2. Remsen, I., Hornberger, G.M., and Moltz, F.J., Numerical Methods in Subsurface Hydrology, Wiley-Interscience (A division of John Wiley and Sons., Inc.) New York, 1971.
3. Walton W.C., Groundwater Resources Evaluation, McGraw-Hill, New York, 1970.

4. Robert Willis & William W.G. Yeh, Groundwater systems planning & management, Prentice hall, Inc., Englewood Cliffs, New Jersey 0762, 1987.

Participatory Field Research Methodology **CE4157**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Research: Meaning, purpose, types of research, stages of research, how to conduct a research, formulation of problem, hypothesis, sampling, designs, method, techniques of data collection, analysis and reporting, ethical responsibilities in social research.

Participatory and field research: Types of participation, participatory meaning, importance of peoples knowledge, emergence of participatory research, participatory research approaches in science and technology, participatory research and development, field practice.

Techniques in field research: Primary data collection, qualitative and quantitative, survey, observation, semi structured interview, questionnaire schedule and field trials, analysis and evaluation, field practice.
Methods of field research: Research methods, Rapid Rural Appraisal (RRA), Participatory Rural Appraisal (PRA), Participatory Learning and Action (PLA), diagramming and mapping, field observation and field trials, analysis and evaluating participatory research and development, some key elements, field practice.
Participatory tools: Situation Query Problem and Response (SPQR), statistical analysis, exercises in the use of concepts and methods, methodology, field practice

Text/ Reference Books:

1. Anderson L. Borum, F., Kristensen. P.H and Karnoe, P.1995. On the art of doing field studies: An experience based research methodology, Copenhagen Business School Press, Denmark.
2. Chambers, R., A. Pacey and L. Thrupp. 1989. Farmer First: Farmer Innovation and Agricultural Research. Intermediate Technology Publications: London.
3. Martin Lengwiler, 2008. Participatory Approaches in Science and Technology: Historical Origins and Current Practices in Critical Perspective Science Technology Human Values 2008; 33; 186 http://sth.sagepub.com/cgi/content/abstract/33/2/186.
4. McAllister, K. and R. Vernooy. 1999. Action and Reflection: A Guide for Monitoring and Evaluating Participatory Research. International Development Research Centre, Ottawa, ON, Canada.
5. Pauline V Young,1984. Scientific Social Surveys and Research Prentice-Hall of India Ltd, New Delhi.
6. Wilkinson &Bhandarkar, 2004. Methodology and Techniques of social Research, 17th edition, Himalaya Publishing House.

Watershed Conservation and Management **CE4158**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Watershed Concepts: Watershed, Need for an integrated approach, influencing factors, geology, soil, morphological characteristics, toposheet, delineation, codification, prioritization of watershed, Indian Scenario.
Soil conservation measures: Types of erosion, water and wind erosion, causes, factors, effects and control, soil conservation measures, agronomical and mechanical, estimation of soil loss, sedimentation
Water harvesting and conservation: Water harvesting techniques, micro-catchments, design of small water harvesting structures, farm ponds, percolation tanks, yield from a catchment
Watershed management: Project proposal formulation, watershed development plan, entry point activities, estimation, watershed economics, agroforestry, grassland management, wasteland management, watershed approach in Government programmes, developing collaborative know how people's participation, evaluation of watershed management
Remote Sensing and GIS for watershed management: Applications of Remote Sensing and Geographical Information System, role of decision support system, conceptual models and case studies

Text/ Reference Books:

1. Ghanashyam Das, Hydrology and Soil Conservation engineering, Prentice Hall of India Private Limited, New Delhi, 2000.
2. Glenn O. Schwab, Soil and Water Conservation Engineering, John Wiley and Sons, 1981.
3. Gurmail Singh, A Manual on Soil and Water Conservation, ICAR Publication NewDelhi, 1982.
4. Suresh, R. Soil and Water Conservation Engineering, Standard Publication, New Delhi, 1982.
5. Vir Singh, Raj, Watershed Planning and Management,Yash Publishing House,Bikaner, 2000.
6. Brooks, K. N., P. F. Ffolliott, H. M. Gregersen and L. F. DeBano. 1997. Hydrology and the Management of Watersheds. Second Edition. Iowa State University Press. Ames, Iowa. 502 pp. Heathcote, I. W. Integrated Watershed Management: Principles and Practice. 1988. John Wiley and Sons, Inc., New York.
7. Lal, Ruttan. 2000. Integrated Watershed Management in the Global Ecosystem. CRC Press, New York.
8. Heathcote, I. W. Integrated Watershed Management: Principles and Practice. 1988. John Wiley and Sons, Inc., New York.
9. DhruvaNarayana, G. Sastry, V. S. Patnaik, "Watershed Management", CSWCTRI, Dehradun, ICAR Publications, 1997.

Urban Water Resources Management **CE4159**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Urban hydrologic cycle: Water in the urban eco-system, urban water resources, major problems, urban hydrological cycle, storm water management objectives and limitations, storm water policies, feasibility consideration.

Urban water resources management: Types of models, physically based, conceptual or unit hydrograph based, urban surface runoff models, management models for flow rate and volume control rate, quality models.

Urban storm water management: Storm water management practices (Structural and Non-structural Management measures), detention and retention concepts, modelling concept, types of storage, magnitude of storage, hydraulic analysis and design guidelines, flow and storage capacity of urban components, temple tanks.

Master plans: Planning and organizational aspects, inter dependency of planning and implementation of goals and measures, socio-economic financial aspects, potential costs and benefit measures, measures of urban drainage and flood control benefits, effective urban water user organizations.

Operation and maintenance: General approaches to operations and maintenance, complexity of operations and need for diagnostic analysis, operation and maintenance in urban water system, maintenance management system, inventories and conditions assessment, social awareness and involvement.

Text/ Reference Books:

1. Geiger, W.F., Marsalek, F., and Zuidena, F.C., (Ed), manual ondrainage in urbanized areas – Vol.1 and Vol.II, UNESCO, 1987.
2. Hengeveld, H. and C. De Voch.t (Ed)., Role of Water in Urban Ecology, 1982.
3. Martin, P. Wanelista and Yousef, A. Yousef., Storm Water Management, John Wiley and sons, 1993.
4. Neil S. Grigg., Urban Water Infrastructure Planning, Management and Operations, John Wiley and Sons, 1986.
5. Overtens D.E. and Meadows M.E., Storm Water Modelling, Academic Press, New York, 1976.

Computational Intelligence for Hydro-systems **CE4160**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Advanced Computing techniques - Computer methods in water resources - Solution to ordinary and partial differential equation using Finite difference and Method of Characteristics- Numerical integration and

differentiation Design of digital models - Visual programming - Graphical user interface - Interactive model concepts.
Artificial intelligence -Heuristic search - Principle of Artificial Neural Network (ANN) - Application of ANN Model to Hydrology and Crop Water Requirement model. Fuzzy Logic concepts and Applications – Genetic Algorithms-Heuristic Optimization techniques.
Digital data management - Data base structure - Data acquisition - Data warehouse - Data retrieval-Data format Attribute - RDBMS - Data analysis - Network data sharing - Statistical Analysis (SYSTAT) - Regression - factor analysis - histogram - scatter diagram - Goodness of fit.
Simulation software in water resources-Surface water models (HMS) - Storm Water Management Models (SWMM) –culvert hydraulic design(HY) – River Analysis system models (HEC-RAS)- MIKE 11, MIKE 21, MIKE FLOOD, MIKE BASIN,MIKESHE model applications –Ground Water Flow models (MODFLOW) – Groundwater transport models.
Simulation models in irrigation water management - Soil water assessment simulation models (SWAT) - Basin simulation models (MITSIM, VASIM) -Real time operation models - Water Resources Information System, Management Information System. Decision support system for Irrigation management.

Text/ Reference Books:

1. Aliev R. A, and Aliev Rashad Soft Computing and its Applications World Scientific Publications Co. Pte. Ltd. Singapore, 2001.
2. JanuszKacprzyk*Applied Decision with Soft Computing* Springer, 2003
3. Carlos A. CoelloCoello, David A Van Veldhuizen, Gary B Lamont, Evolutionary Algorthms for Solving Multi-objective problems, Springer, 2002.
4. TayfurGökmen Soft computing in water resources engineering, WIT Press, Great Britain,UK,20124.
5. John E. Gribbin, Introduction to hydraulics and hydrology with applications for Storm water Management. DELMAR, Thomson Learning, USA,2002.
6. Remson I, Hornberger G.M. and Moiz F.J., Numerical methods in Sub- Surface Hydrology. Wiley Inter Science, 1985
7. Kazda, I., Finite element Techniques in ground water flow studies (with Applications in Hydraulic and Geotechnical Engineering), Elsevier, 1990.
8. Abbott M.B, and Minns A.W. Computational hydraulics Ashgate, London, UK, 2007.
9. Loucks Daniel P., Jery R Stedinger and Douglas, A. Haith, Water Resources systems Planning and Analysis. Prentice Hall Inc., Englewood Clifts, New Jersey, 1981.

Hydrological Elements and analysis **CE4161**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Hydrologic cycle, Climate and water availability, Water balance, Precipitation mechanisms, Measurement of precipitation, Infiltration, Evaporation and transpiration, Surface runoff, Hyetographs, Hydrographs, Derivation of UH, S-curve Change of unit period of UH, Derivation of an average UH, Conceptual models, Traditional analysis vs.hydrological simulation, Monte carlo simulation.
Generation of random numbers, Simulation of systems with random inputs, Developing synthetic unit hydrograph, Development of rainfall runoff relationship, Flow duration curves, Flood routing, Probability distributions, Probability functions for hypothesis testing, Statistical analysis for linear regression, Multiple linear regression, Method of parameter estimation, Return period flood estimation, Estimation of flood discharge for a confidence interval, Regional flood frequency analysis, Risk and reliability concepts, Binominal distribution, Poisson distribution, Design frequencies, Peak over threshold (POT) models, Mechanical energy and fluid potential, Fluid potential and hydraulic head, Darcy's law, Gradient of hydraulic head, Aquifer properties, Equation of groundwater flow.

Text/ Reference Books:

1. K.C. Patra, Hydrology and Water resources Engineering, by Narosa publishing house, New Delhi
2. K. Subramanya, Engineering Hydrology, Tata McGraw Hill Book Company
3. V. P. Singh, "Elementary Hydrology", Prentice Hall of India, Pvt. Ltd., New Delhi.
4. V.T. Chow, Hand book of Applied Hydrology, McGraw-Hill Publishing Company, New York.
5. M.A. Kohlar, J.L.H. Pauluhus, R.K. Linsely, Hydrology for Engineers, Tata McGraw Hill, New Delhi.

Stochastic Hydrology **CE4162**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Probabilistic modelling of hydrological processes: probability concepts, commonly used probability distributions, normal distribution, Log-normal distribution, Pearson type-iii distribution Gumbel distribution. Components of hydrologic time series: trend, test for randomness and trend, turning point test, Kendall's rank correlation test, regression test for linear trend, autoregressive models. Sequential generation of hydrologic information: generation and transformation of random numbers, normally distributed random numbers, Box and Muller's method. Generation of annual flows: persistence absent and present cases, AR & ARIMA models. Generation of monthly stream flows: Thomas-Fiering model. Flood frequency analysis using partial duration series, Flood forecasting: classification of river forecasting, data requirement, flood forecasting models, methods based on statistical approach. Analysis of low flows, characteristics of low flows, frequency distribution of low flows at gauged sites. Risk and reliability concepts in hydrology-computation of risk, application of Binomial and Poisson distributions in risk analysis forecasting models.

Text/ Reference Books:

1. Viessman, W., Knapp, J.W., Lewis, G.L., Harbaugh, T.E. Introduction to Hydrology, T. Harper and Row, Publishers, New York.
2. Box, G.E.P. and Jenkins, G.M., Time series analysis: Forecasting and Control, Holden-Day Inc. (1970).
3. Kottegoda N.T., Stochastic water resources technology, John Wiley and Sons, New York (1979).
4. Patra, K.C., Hydrology and Water Resources Engineering, Narosa publishing House, New Delhi.
5. Larry W. Mays, Water Resources Engineering, John Wiely& Sons, Inc.
6. Chow. V.T., Maidment, D.R. and Mays, L.W., Applied Hydrology, McGraw-Hill, 1988.

Hydraulics and Water Resources Engineering Laboratory **CE4163**

0 - 0 - 2: 1 Credits ***Prerequisites:*** **None**

Flow measurements in channels and pipes, Pipe Transitions, Measurement of velocity profiles in open channels, Measurements of velocity distribution and boundary shear in smooth and rough channels. Experimental Flumes, Venturi Flume flow rate measurement. Measurement of Rainfall, Evaporation, Infiltration, Wind velocity, and Sunshine. Field tests: River velocity measurement techniques, Groundwater flow net analysis, rainfall-runoff transform process.

SEMESTER- II

Computational Fluid Dynamics **CE4251**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Introduction to computational fluid dynamics, application to different branch of science and engineering, governing equations for fluid flow: continuity equation, momentum equation and energy equation, finite difference approach, classification of partial differential equations, parabolic, hyperbolic and elliptic equations, finite difference formulations, 1-dimensional, 2-dimensional partial differential equations and its solutions, explicit finite difference schemes, implicit finite difference schemes, Initial and boundary conditions, significance, of model boundary conditions, grid generation techniques, Von-Neumann stability analysis. solution of governing equations and application to different fluid flow problems.

Text/ Reference Books:

1. J.D. Anderson, Jr. Computational Fluid Dynamics. Mc. Graw Hills
2. K.A. Hoffman and S. T. Chiang. Computational Fluid Dynamics. Engg. Education System.
3. M.B. Abbott and D.R. Basco, Computational Fluid Dynamics. (1989).
4. C.B. Vreugdenhill, Computational Hydraulics (1989).
5. P.S. Huyakern and G. F. Pinder, Computational Methods in sub-surface flows, academic Press, 1983.

Water Resource Systems Analysis **CE4252**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Concept of a system need for systems approach, steps in systems design, assumptions, problem formulation and solution by different optimization techniques: LP, NLP and dynamic programming techniques, one dimensional and multi-dimensional allocation process - optimization in time and space. Application of latest and advanced optimization techniques to design and operation of single and multipurpose reservoirs. Linear and Non-linear case studies. Analysis by simulation- simple examples of single and multipurpose reservoirs and simplified river basin systems. Case studies.

Text/ Reference Books:

1. Vedula, S. Mujumdar, P. P. Water Resources Systems, Modelling Techniques and Analysis, Tata McGraw-Hill. 2005.
2. Hall, Warren, A, and A. Dracup, Water Resources Systems Engineering, Tata McGrah-Hill Pub. Co. Ltd., 1970.
3. Maass, A., M.M. Hufschmidt, R. Dorfman, H. A., Thomas, Jr., S.A. Marglin and G.M. Fair, Design of Water Resources Systems, Harvard University Press, Cambridge, Mass., 1962
4. Helweg, Otto, J., Water Resources Planning and Management, John Wiely and Sons, 1985.
5. Hiller, P.S. and G.I. Lieberman, Operations research, Holden-day Inc., 1974.
6. Loucks Daniel, P., Jery R. Stedinger and Douglas A. Haith, Water Resources System Planning and Analysis, Prentice Hall, Inc. Englewood cliffs, New Jersey, 1981.

Water Resource Planning and Management **CE4253**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

General definitions in water resources planning, purpose of water resources planning and management, general process of planning, reservoir capacity and yield, flow duration curve, reservoir planning, reservoir sediment distribution, cost benefit analysis, conjunctive water use planning, flood routing, reservoir operating rules, river water disputes, integrated river-basin development, inter-basin river water transfers, financial analysis, environmental aspects.

Text/ Reference Books:

1. Goodman, Alvin. S., Principles of Water Resources Planning, Prentice-Hall Inc. Englewood cliffs, NewJersey, 1984.
2. James, L. Douglas, and Robert R. Lee, Economics of Water resources Planning, McGraw-Hill Book Company, 1971.
1. Quentin Grafton, R. and Karen Hussey, Water Resources Planning and Management, Cambridge University Press, 2011.
2. Warnic, C.C., Hydropower Engineering, Prentice Hall Inc., New Jercy, 1984.

ELECTIVE – III, IV

Finite Element Method **CE4201**

4 - 0 - 0: 4 Credits **Prerequisites: None**

Finite element techniques, discretization, energy and variational approaches, basic theory, displacement, force and hybrid models, shape function theory, use of parametric and local coordinates, convergence criteria, numerical integration. Element formulation, 2-D elements, plate-bending elements, introduction to 3-D elements, shell elements, interface elements, boundary elements, infinite elements. Applications, plain stress and plain strain problems, axisymmetric solids, plate and shell structures, and temperature and flow problems, non-linear problems, introduction to iterative and incremental procedures for material and geometrically non-linear problems, examples from plain stress and stability. Programming, organization of

FEM programme, efficient solver, input/output, plotting and mesh generation aspects, pre and post-processors with graphic package for FEM, time dependent problems by explicit and implicit schemes.

Text/ Reference Books:

1. R Dhanraj & Prabhakaran Nair, Finite Element Methods, Oxford University Press, 2007, New Delhi.
2. J.N.Reddy, An Introduction to Nonlinear Finite Element Analysis, Oxford University Press, 2007, New Delhi.
3. R. D. Cook, Concepts and Applications of Finite Element Analysis, John Wiley& Sons, New York
4. C. S. Krishnamoorthy, Finite Element analysis-Theory and Programming, Tata McGraw Hill.
5. O. C. Zienkiewicz and R. L. Taylor, The Finite Element Method, McGraw Hill Publishing Company
6. M. Petyt, Introduction to finite element vibration analysis, Cambridge University Press, UK.
7. T. R. Chandrupatla& A. D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall of India, Pvt. Ltd., New Delhi.

Water Quality Modeling and Control **CE4254**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Water quality description, various characteristics of water, water quality criteria and standards, elements of reaction kinetics, spatial and temporal aspects of contaminant transport, transport mechanism-advection, diffusion, dispersion; River and streams, convective diffusion equation and its application. Estuaries, Estuarine hydraulics, Estuarine water quality models; Lakes and reservoirs, eutrophication; Contaminant transport in unsaturated flows, solute transport models for conservative species, solute transport in spatially variable soils; Contaminant transports in ground water advection, dispersion, one dimensional transport with linear adsorption, dual porosity models, numerical models, bio degradation reaction; Water quality management, socio-economic aspects of water quality management, management alternatives for water quality control, waste load allocation process, lake quality management, ground water remediation

Text/ Reference Books:

1. Thomann and Muller, Principles of surface water quality modeling and control
2. Chapra, Surface water quality modeling
3. Schnoor, Environmental Modeling
4. Thomann, Systems Analysis and Water Quality Management.

Design of Hydraulic Structures **CE4255**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Advanced topics in design and construction of Gravity, earth and Rock-fill dams, Dynamic analysis of gravity dams. Spillways and energy dissipaters, Gates, Sluices, galleries, Contraction joints, Seepage control measures, Principles of foundation treatment. Transients in water conductor systems. Design of hydropower installation components intake structures, water conductor systems, tunnels, surge-tanks, penstocks, valves and anchor-blocks. Types of powerhouse. Underground, Semi-Underground. Turbines and their foundations. Introduction to structural and geotechnical aspects of powerhouse design.

Text/ Reference Books:

1. H. Rouse, Engineering Hydraulics, John Wiley and Sons
2. Varshney, Hydraullic and Irrigation Structures
3. K.R. Arora, Irrigation Water Power and Water Resources Engineering

Climate Change and Water Resources Modeling **CE4256**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Weather and Climate, regional climate downscaling, water for people, climate change and water availability, emerging approaches to climate risk management, case studies: Climate change impact assessment on hydrology and water resources of river basins, impact of climate change on hydropower. Climate change adaptation in water resources and water use sectors, Potential water resource conflicts between adaptation and mitigation, Implications for policy and sustainable development. Assessment of water availability under climate change scenarios. Water resources assessment case studies.

Text/ Reference Books:

1. Fai Fung, C., Ana Lopez, Mark New, Modelling the Impact of Climate Change on Water Resources ISBN: 978-1-4051-9671-0, Wiley-Blackwell, November 2010.
2. Baba, A., Tayfur, G., Gündüz, O., Howard, K.W.F., Friedel, M.J., Chambel, A. (Eds.), Climate Change and its Effects on Water Resources Issues of National and Global Security, Series: NATO Science for Peace and Security Series C: Environmental Security 2011, XVI, 318p. 114 illus., 74 illus. in color.
3. Shrestha, Sangam, Climate Change Impacts and Adaptation in Water Resources and Water Use Sectors, Series: Springer Water, XVI, 119 p. 44 illus., 38 illus. in color, 2014.
4. IPCC Report Technical Paper VI – Climate change and water , 2008.
5. UNFCC Technologies for Adaptation to climate change, 2006.

Irrigation and Drainage Engineering **CE4257**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Basic Soil-Water Physics- Physical properties of soils and water, soil water content and potentials, flow of water in saturated and unsaturated soils; Irrigation development planning- factors affecting irrigation development in the tropics, water sources for irrigation quantity and quality, Irrigation methods selection, soil/hydrologic/crop data needs, soil-water-plant-atmosphere continuum (SPAC), crop/Irrigation water requirements and scheduling; Irrigation network and hydraulics- irrigation systems components, diversion, conveyance and distribution systems; planning and design of irrigation Systems- design and evaluation of surface irrigation systems, volume balance surface irrigation system design, land grading and earthwork calculations, sprinkler irrigation system design and evaluation, drip irrigation system design and evaluation. Drainage of Irrigated Lands- Drainage surveys/investigations, drainage criteria, design discharges, steady and non-steady flow to drains, planning and design surface/subsurface drainage systems- design of surface drainage systems, design of pipe drainage systems, irrigation and drainage structures, pumps for irrigation and drainage, design of canal and appurtenant structures, flow measuring devices.

Text/ Reference Books:

1. Black, C.A. Methods of Soil Analysis, 2nd Ed. ASA Monograph. Madison Wisconsin, 1986.
2. Cuenca, R.H. Irrigation System Design: An Engineering Approach, Prentice Hall, NJ. 1989.
3. Hillel, D. Fundamentals of Soil Physics, Academic Press, 1980.
4. Hoffman, G. J., Howell, T.A. and Solomon, K.H., Management of Farm Irrigation Systems (Monograph), ASAE.,1990.
5. Jensen, M.E. (ed.), Design and Operation of Farm Irrigation Systems, Monograph No. 3, ASAE., 1983.
6. Jensen, M.E., Burman, R.D. and Allen, R.G. (Editors), Evapotranspiration and Irrigation Water Requirements, American Society of Civil Engineers, New York, 1990.
7. Ritzema H. P. (Editor-in-Chief)
8. Drainage Principles and Applications, ILRI publication 16, International Institute for Land Reclamation and Improvement, Wageningen, The Netherlands,1994.
9. Rydzewski, J. R., Irrigation Development Planning: An Introduction to Engineers, John Wiley and Sons Ltd. London, 1987.
10. Smedema, L. K. and D.W. Rycroft, Land Drainage, Cornell University Press, Ithaca, New York., 1983.
11. Walker, W.R. and Skogerboe, G.V., Surface Irrigation – Theory and Practice, Prentice Hall., 1987.

Environmental Impact Assessment of Water Resources Development **CE4258**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Water resources development and environmental issues- environment in water resources project planning- environmental regulations and requirements- The EIA (Environmental Impact Assessment) notification- EIA in project cycle- legal and regulatory aspects in India according to Ministry of Environment and Forests- Types and limitations of EIA-cross sectoral issues and terms of reference in EIA- Participation of Public and Non-Governmental Organizations in environmental decision making- Hydrological and water quality impacts – Ecological and biological impacts – Social and cultural impacts – Soil and landscape changes – Agro economic issues – Human health impacts – Ecosystem changes-EIA team formation – Development of scope, mandate and study design – Base line survey – Check lists – Ad hoc procedures – Network and matrix methods – Semi-quantitative methods – ICID checklist – Economic approaches – Environmental Impact Statement (EIS) preparation- Environmental Management plan: In-stream ecological water requirements - Public participation in environmental decision making – Sustainable water resources development – Ecorestoration – Hydrology and global climate change – Human ecology – Ecosystem services – Environmental monitoring programs.

Text/ Reference Books:

1. Canter, L.W., Environmental Impact Assessment. McGraw Hill International Edition, New York. 1995.
2. Barathwal, R.R., Environmental Impact Assessment. New Age International Publishers, New Delhi. 2002.
3. Petts, J., Handbook of Environmental Impact Assessment, Vol., I and II, Blackwell Science London. 1999.
4. Lawrence, D.P., Environmental Impact Assessment – Practical solutions to recurrent problems, Wiley-Inter Science, New Jersey. 2003.
5. Arnel, N., Hydrology and global environmental change. Prentice Hall, Harlow. 2002.
6. Chari. B., Richa Sharma and S.A. Abbasi, Comprehensive Environmental Impact Assessment of Water Resources Projects : With Special Reference to Sathanur Reservoir Project (Tamil Nadu)/K. Discovery Pub., New Delhi, 2005.
7. UNEP's Environmental Impact Assessment Training Resource Manual -Second Edition, 2002.

Embankment Dam Engineering **CE4259**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Introduction, Investigation of dam sites, Types and advantages of embankment dams, Factors affecting the design of embankment dams, Design concept, Treatment of foundation for embankment dams, Grouting, Materials for construction, Safety criteria, Theoretical analysis of seepage through embankment dams (with filter and without filter) and its application, flow nets in dams, Seepage control, Anti-seepage elements (Active and Passive), Stability analysis including seismic stability, Failure of embankment dams, Typical problems and their solutions in embankment dams, Hydraulic and semi hydraulic fill dams, Rockfill dams, Head race canal and Hydraulic turbine.

Text/ Reference Books:

1. Engineering for Embankment Dams - Bharat Singh.
2. Engineering for Dams [Vol. I, II & III] - Creager, Justin & Hinds.
3. Dam Engineering - J. L. Sherad& et.al.
4. River and Canal Levees – P. Peter, Elsevier Publishing.

Ground Water Flow through Porous Media **CE4260**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Introduction, Occurrence of ground water, Flow and storage characteristics of aquifers, Darcy's law, Anisotropy and heterogeneity, Governing equations for ground water flow, Dupuit-Forchheimer assumptions, General differential equations governing ground water flow, Analytical solutions, Different types of wells, Well hydraulics, Steady and unsteady state solutions for confined, unconfined and leaky aquifers, effect of boundaries, method of images, Pumping test analysis, Interference of wells, Ground water conservation, artificial recharge, Ground water quality, Pollution of ground water, sources, remedial and preventive measures, Ground water flow Modeling.

Text/ Reference Books:

1. D.K. Todd, Groundwater Hydrology, John wiley and Sons
2. H.M. Raghunath, Ground Water, Willy Eastern Ltd.
3. C. Fitts, Ground Water Science, Elsevier Publications, U. S. A.
4. P. P. Raj, Geotechnical Engineering, Tata McGraw-Hill
5. A. Jumikis, Soil Mechanics, East West Press Pvt Ltd.

Hydraulics of Sediment Transport **CE4261**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Sediment properties; initiation of motion; bed forms; bed load and its estimation; effective bed roughness; armouring; suspended load and its estimation; total load; transport of sediment due to unsteady flow; meandering of rivers; braided river; local scour at different structures; sediment sampling; density current; mathematical models of sediment transport; effect of coherent turbulence on sediment transport. Design of alluvial channels; Reservoir sedimentation-fixation of reservoir capacity, determination of sediment yield at a river site, reservoir sediment control.

Text/ Reference Books:

1. Grade, R.J., and Rangaraju, K.G. Mechanics of Sediment Transport and Alluvial Stream Problems.
2. Graf, W.H., Hydraulics of Sediment Transport, McGraw-Hill Book Company, 1971.

Hydropower Engineering **CE4262**

4 - 0 - 0: 4 Credits ***Prerequisites:*** **None**

Comparison of hydropower and thermal power, combined power systems and grids. Basic terms and definitions - gross head, net head, operating head, hydraulic efficiency, of plant, overall efficiency of hydropower scheme, overall efficiency of the plant, installed capacity, capacity factor, firm power, power factor, utilization factor, diversity factor. Assessment of available hydropower, necessity of storage and pondage, essential stream flow data, flow duration curve, power duration curve, use of flow duration and power duration curves. Types of hydropower plants, general arrangement of a hydropower project, intakes, types of intakes, intake gates and valves, force required to operate the gate, conveyance systems, fore-bay, surge tanks, power house, tail race, and selection of turbine.

Text/ Reference Books:

1. C.S.P. Ojha, R. Berndtsson, and P.N. Chandramouli, "Fluid Mechanics and Machinery", Oxford University Publication, 2010.
2. K.R. Arora, Fluid mechanics, Hydraulics and Hydraulic machines, 5th edition, standard publisher distributors, 2005.

Computational Laboratory **CE4263**

0 - 0 - 2: 1 Credits ***Prerequisites:*** **None**

Problem solving in Computational Fluid Dynamics (CFD)
Soft computing using Hydrologic software: SWAT, HEC-HMS, HEC-RAS, HEC-GeoRAS, SWMM, MIKE 11, MIKE 21, MIKE FLOOD, MIKE BASIN, MIKE SHE, MODFLOW, EPANET-2, WATERGEMS, etc.
Soft Computing by Remote Sensing and GIS software: Q-GIS, ERDAS IMAGINE, ArcGIS, GRASS.