CIVIL ENGINEERING

M.E (Water Resources Engineering & GIS)

I-SEMESTER

Course Code	Course Title	Teaching Hours per week		Duration of Exam (Hrs.)	Marks			
		Theory	Lab		External	Sessional	Total Marks	Credits
WRE 1.1	Computational Hydraulics	4	--	3	70	30	100	5
WRE 1.2	Channel & Fluvial Hydraulics	4	--	3	70	30	100	4
WRE 1.3	Applied Hydrology	4	--	3	70	30	100	4
WRE 1.4	Hydraulic Structures & Materials	4	--	3	70	30	100	5
WRE 1.5	Computational Fluid Mechanics Laboratory	--	3	--	50	50	100	3
Total		20+3=23			330	170	500	21

II-SEMESTER

Course Code	Course Title	Teaching Hours per week		Duration of Exam (Hrs.)	Marks			
		Theory	Lab		External	Sessional	Total Marks	Credits
WRE 2.1	Water Quality Modelling	4	--	3	70	30	100	4
WRE 2.2	Watershed Behaviour and its conservation	4	--	3	70	30	100	4
WRE 2.3	Remote Sensing & GIS Applications for Water Resources Engineering	4	--	3	70	30	100	5
WRE 2.4	Planning, Management & Economics of Water Resource Projects	4	--	3	70	30	100	4
WRE 2.5	Hydraulics & Environmental Engg. Lab	--	3	--	50	50	100	3
Total		16+3=19			330	170	500	20

III-SEMESTER

Course Code	Course Title	Teaching Hours per week		Duration of Exam (Hrs.)	Marks			
		Theory	Lab		External	Sessional	Total Marks	Credits
WRE 3.1	Elective I	4	--	3	70	30	100	4
WRE 3.2	Urban Storm Water Drainage	4	--	3	70	30	100	4
WRE 3.3	Environmental Impacr Assessment of Water Resource Projects	4	--	3	70	30	100	4
WRE 3.4	GIS Laboratory	--	3	--	50	50	100	3
WRE 3.5	Elective II	4	--	3	70	30	100	4
WRE 3.6	Thesis/ Dissertation	--	3		--	--	--	--
Total		20+6=26			300	200	500	10

IV-SEMESTER

WRE 4.1	Thesis/Dissertation	100 marks	Credits:25
GRAND TOTAL		1600	80

LIST OF ELECTIVES

ELECTIVE-I			ELECTIVE-II	
WRE 3.1 - A	Hydroinformatics		WRE 3.5-A	Conjunctive Water Resources Planning
WRE 3.1 -B	Flood Forecasting		WRE 3.5-B	Ground Water Flow and Contaminant Transport
WRE 3.1 -C	Subsurface Investigations		WRE 3.5-C	Irrigation Water Systems and Management

CIVIL ENGINEERING
M.E. (Water Resources Engineering & GIS)
WREGIS – Four Semester Course

WRE 1.1 COMPUTATIONAL HYDRAULICS			
No. of Periods per week:	4L + 0T	Internal Marks:	30
		Univ. Exam. Marks:	70
		Duration of Univ. Exam:	3 Hrs.

PART – A

Statistical Methods in Hydraulics:

Importance of statistical and Probability Analysis, Statistical variables, Frequency, Probability and Statistical Distributions for Discrete Random variables and Continuous Random Variables.
Statistical Parameters –Measures of Central Tendancy, Measures of variability and measures of Skewness; Statistical moments, Statistical Homogenity –Time homogeneity and Space homogeneity.
Probability and Distributions – Basic definintions of probability – random variable- discrete probability distributions – contionuous - distribution functions – expectation – repeated traits – binomial distribution – Poisson distribution – Normal distribution.
Reliability Analysis-Sampling Reliability and Prediction of Reliability; Theoretical Justifications- Type-I Extremal Distribution, Lognormal Distribution, Exponential Distribution and Logextremal Distribution.
Correlation and Rank correlation – Linear Regression – Multiple linear Regression – Curvilinear Regression.

PART – B

Introduction to programming language C:

Overview of C language, contracts, variables and data types. Operators and expressions. Arthimatic operators, Relational operators, logical operators, assignment operators, increments and decrements operators, conditional operators, special operators, bitwise operators.
Managing input and output operations.
Decision making and branching. If statements, switch statement, conditional operator statement. Devision making and looping. While loop, Do loop, for loop, nested loops.
Arrays- single dimensional arrays.
Handling character string functions. Various built in string functions.
User defined functions, all kinds of functions.
Structures and unions.
Pointers and pointer operators.
Files; file handling function sequential files, random access files.

Text books:

1. Ven Te Chow, Handbook of Applied Hydrology, McGH Publishers.
2. Dr. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, Nai Sarak, Delhi.
3. E. Balaguru Samy, Programming in ANSI C.

Reference books:

1. Ven Te Chow Handbook of Applied Hydrology, McGH Publishers.
2. Dr. P. Jayarami Reddy, Stochastic Hydrology, Laxmi Publications, New Delhi.
3. R.S. Varshney, Engineering Hydrology, Nem Chand & Bros., Roorkee.
4. Vimala and Venugopal, Programming with C.

WRE 1.2 CHANNEL & FLUVIAL HYDRAULICS			
No. of Periods per week:	4L + 0T	Internal Marks:	30
		Univ. Exam. Marks:	70
		Duration of Univ. Exam:	3 Hrs.

Review of Fundamentals of Hydraulics-Continuity Equation, Bernoullis Equaion and Impulse –Momentum Equation.
Introduction to Open Channel Flows- Basic Features, Uniform Flow and computation of Normal Depth, Specific Energy-Depth Relationship, Critical flow and Computation of Critical Depth, Hydraulic Jump.
Steady State Gradually-Varied Flow- Governing Differential Equation, Classification of GVF Profiles, Computation of Profiles.
Transient Gradually-Varied Flow- Saint Venant Equations, Kinematic Wave Theory, Flood routing Through Channels- Muskingum Method.
Fluvial Hydraulics, Incipient Condition, Bed Load, Suspended Load, Bed Forms & Field Measurements.

TEXT BOOKS AND REFERENCE BOOKS:

Subramanya, K., Flow in Open Channels, Tata Mc Graw Hill, 1986.
Garde , R.J. and Rangaraju, K.G., Mechanics of Sediment Transport and Alluvial Stream Problems.
Chow,V.T., Open Channel Hydraulics, Mc Graw Hill, Tokyo, 1959.
Rangaraju, K.G., Flow through Open Channels.

WRE 1.3 APPLIED HYDROLOGY			
No. of Periods per week:	4L + 0T	Internal Marks:	30
		Univ. Exam. Marks:	70
		Duration of Univ. Exam:	3 Hrs.

Introduction: Hydrologic Cycle - the global phenomenon, the hydrologic model on a watershed scale, water balance, water resources and availability; History and scope of Hydrology;
Precipitation: Earth's revolution, seasons, and atmospheric circulation; Formulation, types and distribution, Presentation and processing of data – Consistency and missing data, depth, area and duration; Mean rainfall – isohyetal and trend surface methods, confidence limits and comparison of averages; Frequency analysis – normal and lognormal distributions, frequency plotting, goodness of fit, climate classification, rain gauge network;
Evaporation: Methods of calculation – energy balance, aerodynamic methods; evapo-traspiration potential; Consumptive use, water requirement of crops; soil water balance and climate.
Subsurface Water: Unsaturated flow, moisture flux, Infiltration - rates, capacity., Measurement, Horton's and Philiph's equations; Green-Ampt method, Ponding time, surface runoff and infiltration indices.

Runoff Hydrology: Wateshed processes; new concepts, surface runoff- Honton's flow, variable source area theory – subsurface flow – flow through matrix and pipes; Stream flow components hydrographs and separation; flow recession; unit hydro-graph theory, derivation, S-curve and applications; travel time. Catchment response, factors influencing run off..

Groundwater Hydrology: Occurrence of groundwater. Vertical distribution of groundwater, zone of aeration, zone of saturation, types of aquifers, storage coefficient. Groundwater movement; Darcy's law, permeability, hydraulic conductivity, anisotropic aquifers, groundwater flow direction.
Application of GIS for hydrological studies (introduction only)

TEXT BOOKS:
1. Linsely R.K and others, "Hydrology for Engineering", McGraw Hill, 1952.
2. Linsely R.K. and others, "Engineering Hydrology", McGraw Hill, 1949
3. Subramanya K., "Engineering Hydrology", Tata McGraw Hill, 1998.

REFERENCE BOOKS:

1. Weissman (J) W. and others, "Introduction to Hydrology", Harper, and Row
2. Mutreja, K.N., "Applied Hydrology", Tata McGraw Hill, 1986
3. Chow V.T. (ed.) "Hand book of Hydrology", McGraw Hill, 1988
4. Chow V.T. and others, " Applied Hydrology", McGraw Hill, 1989
5. Hann C.T., "Statistical methods in Hydrology", A.E.W. Press, 1977

WRE 1.4 HYDRAULIC STRUCTURES & MATERIALS			
No. of Periods per week:	4L + 0T	Internal Marks:	30
		Univ. Exam. Marks:	70
		Duration of Univ. Exam:	3 Hrs.

Design Principles of Storage Works:
Recapitulation of Planning, Analysis and Design of Gravity Dams; Design of Non overflow and overflow sections based on multiple step method, Design principles and construction practices of Earthen dams.
Recapitulation of Design principles of weirs on permeable foundations, Regulators -Functions of Regulators, Head Regulators and Cross Regulators-Hydraulic Design of Regulators.
Cross Drainage Works- Types of C.D.Works and choice of the type, Design of C.D.Works.

Hydropower Structures:

(A) Intake Structures, (B) Trash Racks, (C) Penstocks (D) Surge Tanks

Miscellaneous Hydraulic structures:

(A) Water supply works, (B) Infiltration Wells, (C) Clarifloculator and (D) R.C.C. Water storage tanks and sumps.

Materials:

(A) Cements, Aggregates, Admixtures and Chemicals, Fresh Concretes, Hardened Concrete; Special Concretes
Strength of Concrete, Concrete Mix Design.

(B) Geotextiles and Fibre reinforced plastics.

TEXT BOOKS:

1. B.C. Punmia, Irrigation & Water power Engg..
2. S.K. Garg..Irrigation Engg & Hydraulic Structures
3. Varshney, Hydro Power Structures.
4. by I.C. Syal and R.K. Ummat., Behaviour, Analysis and Design of Structural Elements.
5. M.S. Chetty, Concrete Technology Theory and Practice.

REFERENCE BOOKS:

1. P. Dayaratnam , Design of Reinforced Concrete Structures
2. S. Ramamrutham, Design of Reinforced Concrete Structures .

WRE 1.5 COMPUTATIONAL FLUID MECHANICS LABORATORY			
No. of Periods per week:	L + 3P	Internal Marks:	50
		Univ. Exam. Marks:	50
		Duration of Univ. Exam:	3 Hrs.

Developing and executing programmes using C-language for the following problems related to fluid mechanics:

1. Pipe network analysis using Hardy- Cross method..
2. Pipe friction computations.
3. Gradually varied flow problems.

4. Hydraulic jump computations.
5. Unit hydrograph computations.
6. Flood routing. (Muskingum method)
7. Water Hammer Analysis

WRE 2.1 WATER QUALITY MODELLING			
No. of Periods per week:	4L + 0T	Internal Marks:	30
		Univ. Exam. Marks:	70
		Duration of Univ. Exam:	3 Hrs.

Introduction to Environment Overview; Components of environment and their interaction; Uses of water.

Water Quality Parameters: Concepts & Analysis Impurities and water quality characterisation; Physical, Chemical and Biological parameters; Analytical estimation;
Movement of pollutants in aquatic environment, Water quality issues; Transport and transformation processes in surface and groundwater systems; water quality modeling.

Modeling Concept, Process and Classification;

Groundwater quality modeling: Dispersion, flow equations, saturated and unsaturated flow. Groundwater modeling techniques; porous media models, analog models, electrical analogy models, digital computer models.

Surface water quality modeling: Completely mixed systems - Mass balance and steady state equation/ solutions. Euler's method, Runge-Kutta method. Incompletely Mixed Systems – Diffusion- Fide's first law. Steady state conditions- plug flow & mixed flow systems. Time variable conditions- plug flow, randomwalk and spill models. Transport and varaiation of dissolved oxygen- Streeter-Phelps equation and modeling of chemical parameters- modeling ph, toxics, metals.(oxygen sag, BOD, Henry's law, Ideal gas law, DO saturation, BOD model).

Water quality legislation and management Water quality criteria and standards; National and International perspective; Surface and groundwater quality management

TEXT-BOOKS:

1. Water Quality Modelling By Steven.C.Chapra, McGH.
2. Groundwater Hydrology, David Keith Todd, John Wiley & Sons.
3. Chapman, D., (Ed.), Water quality assessments", 2nd Ed., E&FNSPON (Imprint of
4. Chapman & Hall, USA)- Pub. on behalf of UNESCO, WHO, UNEP, 1992.
5. Sawyer, C.N., & McCarty, P.L., Chemistry for environmental engg., 3rd Ed., McGraw
6. Hill, 1987.
7. Manobam, S.E., Environmental science & technology, Lewis Pub., 1997
8. Odum, H.T., Fundamentals of ecology, Oxford & IBH, 1975.
9. Fried, J.J., Groundwater Pollutions : Theory, Methodology, Modelling and Practical rules,
10. Elsevier Scientific Pub. Co., 1975.
11. James, A., Mathematical Models in Water Pollution Control, John Wiely, 1978.
12. Jorgensen, S.E., Application of Ecological Modelling in Environmental Management, Part A & B, Elsevier Scientific Pub. Co., 1983.
13. Thomann, R.V. & Mweller, Principles of Surface Water Quality Modelling & Control, Harper & Row, 1987.

WRE 2.2 WATERSHED BEHAVIOUR AND ITS CONSERVATION PRACTICES			
No. of Periods per week:	4L + 0T	Internal Marks:	30
		Univ. Exam. Marks:	70
		Duration of Univ. Exam:	3 Hrs.

Soil and Water – Issues related to plant life like composition of soil, water requirement of crops, necessary conditions for plant growth etc.
Soils, their origin and classification.
Land classification for WM, Land capability rating, determination of land capability class, land capability and suitability surveys.
Watershed Behaviour – Physical elements of a watershed, effects of land use changes on hydrological cycle component
Concept of vegetative management of water yield and quality.
Watershed Experiments, extrapolation of results from representative and experimental basins, Regional studies
Soil erosion – problem, types, conservation, and control measures in agricultural and non-agricultural land.
Water conservation and Harvesting – Agronomical measures in soil and water conservation. Examples and critical reviews.
Inventory techniques for precipitation runoff, soil, timber, range-land and wild life
Water harvesting techniques – Elements, Development of modern harvesting Techniques
Estimation of peak runoff rate
Land capability classification
Erosion process – Factors affecting erosion, Types of erosion, Assessment of erosion,
Control measures for erosion
Conservative practices – Objective and general practices, land and soil classification, identification of critical areas
Watershed Management – Objectives of Planning Watershed Projects Guidelines for Project Preparation Approach in Govt. programmes, people's participation, conservation farming, watershed-management planning, identification of problems, objectives and priorities, socioeconomic survey, use of tools like GIS.
Watershed Modelling : Runoff components –Simple parametric models – Curve Number Method, variable source area models; quasi- physically based models; a simple physically based model.

TEXT BOOKS & REFERENCE BOOKS :

1. Brooks, K.N., Ffolliott, P.F., Gregerson, H.M. and De Bano, L.F., Hydrology and Management of Watersheds, Iowa State University Press, 1991.
2. Frevert, R.K., Schwab, G.O., Edminster, T.W. and Barnes, K.K., Soil and water conservation Practices, John Wiley and Sons, New York, 1990.
3. Lee. R., Forest Hydrology.
4. Guidelines for watershed Management – F.A.O. Conservation Guide No.l.
5. More Water for Arid Lands – Promising Techniques and Research opportunities – National Academy of Sciences.
2. Water shed Management – B.M. Tideman
3. Modern physical geography – Strahler A.N. and Strahler A.H
4. Dantzig, G.B., Linear programming and extensions, Princeton University Press, Princeton, New Jersey, 1963
5. Hall, W.A. and Dracup, J.A., Water resources systems engineering, Mc Graw Hill, 1970.

10. Hexem, R.W. and Heady E.O., Water production functions for irrigated agriculture, Iowa State University Press, 1978.
11. James, L.D. & Robert, R. L., Economics of Water Resources Planning
12. Lee, S.M., Linear optimization for management, Petrocelli/ Charter, New York, 1976.

WRE 2.3 REMOTE SENSING AND GIS APPLICATION TO WATER RESOURCES ENGINEERING			
No. of Periods per week:	4L + 0T	Internal Marks:	30
		Univ. Exam. Marks:	70
		Duration of Univ. Exam:	3 Hrs.

INTRODUCTION TO REMOTE SENSING; Definition, Principle of Remote Sensing, History of Development of Remote Sensing, Stages in Remote Sensing, Electromagnetic Radiation and the Electromagnetic Spectrum, Interactions with the Atmosphere, Atmospheric Scattering, Atmospheric Absorption, Atmospheric Windows, Refraction, Interaction of EMR with the Earth's Surface, Reflection, Transmission, Spectral Signature.
Remote Sensing Systems, Remote Sensing from Space, Remote Sensing Sensors, Resolution, Imaging sensors, Optical Infrared (OIR) Imagers, Optical Sensors, Thermal Sensors, Microwave Sensors, Active Microwave Sensors, Data Preprocessing, Remote Sensing in India.

INTRODUCTION TO IMAGE INTERPRETATION; Basic Principles of Image Interpretation, Elements of Image Interpretation, Techniques of Image Interpretation, Interpretation Keys, Introduction to Digital Image Processing, Digital Image- Image Rectification And Registration- Geometric Correction, Image Enhancement Techniques (only concepts), Image Classification - Unsupervised Classification and Supervised Classification. Digital Photogrammetry - Stereo Images from Satellites - Digital Ortho photos (Only definitions).

GEOGRAPHIC INFORMATION SYSTEMS (GIS); Definitions and related technology, GIS Operations, GIS Elements, GIS Concepts and Practice, Map projection and Coordinate system.
VECTOR DATA MODEL: Introduction, Vector Data Representation, Geometric Objects, Topology.
SPATIAL DATA EDITING: Introduction, Type of Digitizing Errors, Location Errors, Topological Errors, Topological and Non–Topological Editing, Topological Editing, An Overview, Correction of Errors.
ATTRIBUTE DATA INPUT AND MANAGEMENT: Introduction, Attribute Data in GIS, Linking Attribute Data and Spatial Data, Type of Attribute Data, The Relational Database Model Normalization, Type of Relationship.
RASTER DATA: Introduction, Elements of the Raster Data Model, Types of Raster Data, Satellite Imagery, Digital Elevation Models, GIS Software Specific Raster Data, Raster Data Structure, Projection and Geometric Transformation of Raster Data, Data Conversion, Integration of Raster and Vector Data.

VECTOR DATA ANALYSIS: Introduction, Buffering, Applications of Buffering, Map Overlay, Feature Type and Map Overlay, Map Overlay Methods, Slivers, Error Propagation in Map , Overlay, Distance Measurement, Map Manipulation,

RASTER DATA ANALYSIS: Introduction, Analysis Environment, Local Operations, Local Operations with a Single Grid, Local Operations with Multiple Grids, Neighborhood Operations, Zonal Operations.

TERRAIN MAPPING AND ANALYSIS: Introduction, Data for Terrain Mapping and Analysis, DEM, TIN, Terrain Mapping, Contouring, Vertical Profiling, Hill Shading, Hypsometric Tinting, Perspective View, Terrain Analysis, Slope and Aspect, Surface Curvature, View shed Analysis, Grid versus TIN.

GIS MODELS AND MODELING: Introduction, GIS Modeling, Binary Models, Index Models

Remote Sensing & GIS application in water resources engineering.

TEXT BOOKS :

1. Fundamentals of Remote Sensing 2nd Ed – George Joseph, University Press, New Delhi.
2. Introduction to Geographic Information systems – Kang tsung chang, Tata Mc.G.H. publications, New Delhi.

REFERENCE BOOKS:

1. Remote Sensing of the Environment – An earth resource prespective – John R. Jensen, Pearson Education, New Delhi.
2. Aronoff, S. 1989. Geographic information Systems: A Management Perspective. Ottawa: WDL publications.
3. Bonham – Carter, G,F. 1994. Geographic Information Systems for Geoscientists: Modeling with GIS. New York: Pergamon Press.

4. Burrough, P.A and R.A. McDonnell. 1998. Principles of Geographical Information
5. Systems. Oxford: Oxford University Press.
6. Lo, C.P., and Albert K.W. Young concepts and Technologies of Geographic Information Systems, Prentice hall of India (Pvt) Ltd, New Delhi.
7. Lillesand, T.M. and Kieffer, Remote sensing and image interpretation, Joh Wiley and Sons, New York, 1987.
8. John R Jensen : Introductory Digital Image processing , Prentice Hall, New Jersey.
9. Farsworth, R.K., Bawetl, E.C. & Dhanju, M.S., Application of remote sensing to hydrology including groundwater, IHP, UNESCO, 1984.

WRE 2.4 PLANNING, MANAGEMENT & ECONOMICS OF WATER RESOURCES PROJECTS			
No. of Periods per week:	4L + 0T	Internal Marks:	30
		Univ. Exam. Marks:	70
		Duration of Univ. Exam:	3 Hrs.

(a) Planning & Management of Water Resources Projects

Introduction to the fundamentals of water resource system analysis, involving the determination of the optimal dimensions, outputs and operating policies of water resource projects.
Introduction ; Reservoir Capacity & Yield ; Flow-Duration Curve ; Reservoir Planning
Reservoir Sediment Distribution ; Cost Benefit Analysis ; Conjunctive Water-Use Planning
Flood Routing ; Reservoir Operation ; River Water Disputes ;
Integrated River-Basin Development ; Inter-Basin River Water, Transfers ; Environmental Aspects
Overview of methodologies of analysis. Use of optimisation and simulation techniques for solving water resources problems. Examples in water distribution systems, flood management, river basin planning for irrigation and hydroelectric power. The storage yield relationship.

(B) Engineering Economics

Objectives & scope of Engineering Economics, Managerial Economics, Interest and time-value of money, Depreciation, Economic life.
Demand analysis and forecasting. Cost concept, Annual cost comparison, Present worth, Production Functions, Pricing policies, pricing methods, price forecasting.
Profit, measurement of profit, profit planning & forecasting, Break-even analysis, Return on investment, Rate of return. ; Mathematics of Finance ; Discounting Techniques ; Estimation of Costs
Estimation of Benefits ; Graphical Optimization ; Systems Approach
Multi Objective Analysis ; Financial Analysis ; Cost Allocation ; Case Studies
Capital budgeting, cost of capital, project appraisal.

TEXT BOOKS & REFERENCE BOOKS:

1.Goodman, A.S., Principles of Water Resources Planning, Prentice Hall Inc., New Jercy, 1984.
2.James, L.D. and Lee, R.R., Economics of Water Resources Planning, Mc Graw Hill, 1971.
3.Warnic, C.C., Hydropower Engineering, Prentice Hall Inc., New Jercy, 1984.
4. Goodman, A.S., Principles of Water Resources Planning, Prentice Hall Inc., New Jercy, 1984.
5. James, L.D. and Lee, R.R., Economics of Water Resources Planning, Mc Graw Hill, Inc., 971.
6. Chaturvedi, Water Resources Systems, Planning & Development :
7. Hall & Dracup, Water Resources Systems
8. Barish N. Norman, Economic Analysis.
9. Varshney, R.L. & Maheshwari, K.L., Managerial Economics.

WRE 2.5 HYDRAULICS AND ENVIRONMENTAL ENGG. LABORATORY			
No. of Periods per week:	4L + 0T	Internal Marks:	30
		Univ. Exam. Marks:	70
		Duration of Univ. Exam:	3 Hrs.

1. Hydraulic Jump in horizontal and rectangular channels.
2. Gradually Varied Flow Profiles.
3. Studies on Groundwater flow and Well hydraulics.
4. Flow past Bluff bodies, Airfoil and Cylinder.
5. Principles of measurement and testing of water for parameters like pH, TDS, NO_3 , PO_4-P, Hardness, Turbidity, residual chlorine, DO, Chlorides, Jar test for coagulant dosing.
6. COD, BOD, SS, VSS, heavy metals using AAS, Microscopy.
7. Air for SPM, RSPM, NO_2 & SO_2 using High volume sampler, CO, NO_X , SO_2 using continuous analysers, Noise measurement using SLM**. (Demo only)**

WRE 3.1-A HYDROINFORMATICS			
No. of Periods per week:	4L + 0T	Internal Marks:	30
		Univ. Exam. Marks:	70
		Duration of Univ. Exam:	3 Hrs.

Overview of numerical engines/ techniques including tools, environments and languages
Integration of different interfaces ; Spatial decision support systems and GIS;
Emerging techniques in hydro-informatics; Hydrological applications.

TEXT BOOKS :

1. Rao, V.B. and Rao, H.V., Neural Network and Fuzzy logic, BPB Publications, New Delhi,
2. Babovic, V and Larsem, L.C.; Hydroinformatics '98, AA Balkema, The Netherlands, 1998.
3. Cadoux, J. & Heywood, D.I., Geographic Information, Taylor & Frances Ltd., London, U.K.
4. Fu, L., Neural Networks and fuzy logic, Mc Graw-Hill Inc., 1994.
5. Burrough , D.A., Geographic Information System.

WRE 3.1 –B FLOOD FORECASTING			
No. of Periods per week:	4L + 0T	Internal Marks:	30
		Univ. Exam. Marks:	70
		Duration of Univ. Exam:	3 Hrs.

Objective, importance, historical development and classification of hydrological forecasts
Data Collection and flood forecasting network design ; Data Transmission; Physically based models
Graphical and statistical models; Stochastic models and adaptive filter models; UH and SCS based deterministic models; Flood forecasting using artificial neural network; Watershed models
Updating, verification and dissemination of forecast

TEXT BOOKS :

1. Anderson, M.C., Burt, T.P. , 'Manual on flood forecasting', New Delhi, 1985.
2. Central Water Commission, 'Hydrological forecasting', John Willy and Sons, 1989.
3. WMO, 'Automatic collection and transmission of hydrological observations', Operational Hydrology report no. 2, Geneva, Switzerland, 1973.
4. WMO, 'Inter comparison of conceptual models used in operational hydrological forecasting'. Geneva, Switzerland. Operational Hydrology report no. 7, 1975.

WRE 3.1 –C SUBSURFACE INVESTIGATIONS			
No. of Periods per week:	4L + 0T	Internal Marks:	30
		Univ. Exam. Marks:	70
		Duration of Univ. Exam:	3 Hrs.

Introduction & broad classification of subsurface methods

Direct Methods

Excavation & Pitting; Well Drilling Techniques; Drill Stem Testing; Geological Well Logs

Indirect Methods

Geophysical Well Logging ,Electrical Well logging methods : Normal & Lateral Resistivity Logs, Self Potential Logs, Induction & Micro focussed logs; electrical logging practices evaluation of aquifer parameters

Radiation logging (Natural gamma, neutron & gamma gamma logging) - Accoustic logs

Caliper logs & Dipmeter surveys, & their applications in groundwater prospecting

TEXT BOOKS :

1. Cambell, M.D. & Lehr, Water Well Technology, Mc Graw Hill Book Co, 1973.
2. E.E. Johnson, Inc. UOP Div, Groundwater & Wells, E.E. Johnson Inc., 1975.
3. Keys, W.S. & McCary, L.M., Application of Bore hole geophysics to Water Resources Investigations Tech. of Water Resources Investigations, U.S. Geol. Survey. Book 2, EI., 1971.
4. Lynch, E.J., Formation Evaluation, Harper & Row, 1962.
5. Moore, C.A. Handbook of Subsurface Geology, Harper & Row, 1968.
6. Pirson, S.J., Geologic Well log analysis, (Gulf Publishing Co.), 1977.

WRE 3.2 URBAN STORM WATER DRAINAGE			
No. of Periods per week:	4L + 0T	Internal Marks:	30
		Univ. Exam. Marks:	70
		Duration of Univ. Exam:	3 Hrs.

Introduction to drainage problems in different climates: Urbanisation, its effects and consequences for drainage-interaction between urban and peri-urban areas Process of urbanisation and influence on hydrologic cycle

Planning concepts and system planning: Objectives of urban drainage and planning criteria, drainage and system layout. Planning tools and data requirement, drainage master plan, examples for drainage structures.

Review of Hydrologic and hydraulic principles: Urban hydrologic cycle, hydrologic principles, Rainfall analysis in Urban environment and design storm, hydraulic principles, hydrodynamic principles.

Urban Runoff computations : Empirical, Time-area and unit hydrograph approaches

Design of drainage system elements: Hydraulic fundamentals, infiltration and on-site detention of stormwater, design of sewerage and drainage channels, design of appurtenances, road drainage, design of pumping stations.

Control of stormwater pollution: Pollution build-up and washoff process with reference to urban drainage systems. Source control in commercial and industrial complexes, storage options - dry and wet ponds, biological treatment of wastewater, chemical treatment of stormwater.

Operation and maintenance of urban drainage systems: Maintenance requirement for different structures, maintenance planning, cleaning of sewers and drains, inventory of damages, repair options.

Urban drainage : Kinematic wave theory approach

Introduction to urban watershed softwares Hydrologic Cistern, water conservation and ecological aspects Water harvesting

TEXT-BOOKS:

1. Chow, V.T., Handbook of Applied Hydrology : A Compendium of Water resources
2. Gupta, R.S., Hydrology and hydraulic systems, Prentice Hall, Englewood cliffs, NJ 07632.

3. Urban Hydrology : Hall, M.J.
4. Hydrology : Viesmann & Knapp

WRE 3.3 ENVIRONMENTAL IMPACT ASSESSMENT OF WATER RESOURCES PROJECTS			
No. of Periods per week:	4L + 0T	Internal Marks:	30
		Univ. Exam. Marks:	70
		Duration of Univ. Exam:	3 Hrs.

Water resources development - an overview.
Impact types: beneficial & adverse, primary, secondary, long-term, short-term, reversible, and irreversible
Procedural requirement for EIA and clearance - Indian Scenario
EIA - general, purposes principles and processes; Identification, prediction and assessment steps in EIA - EIA approaches and techniques; Data requirement for EIA; Hydro-indices; Case studies

TEXT BOOKS :

1. Biswas, A.K. and Aggrawal, S.B.C., Environmental Impact Assessment for Developing Countries.
2. Canter, L., Environmental Impact of Water Resources Projects.
3. Munn, R.E., Environmental Impact Assessment; Principle and Procedure.
4. Ray, S.G. & Wooten, D.C., Environmental Impact Analysis Handbook.
5. Saxena, K.D., Environmental planning, policies & programmes in India, Shipra Publishers, Delhi.

REFERENCE BOOKS :

1. Patrick Mc Cully; Silenced Rivers ,Orient Longman Publications.
2. Canter, L., Environmental Impact of Water Resources Projects.
3. Munn, R.E., Environmental Impact Assessment; Principle and Procedure.
4. Ray, S.G. & Wooten, D.C., Environmental Impact Analysis Handbook.
5. Saxena, K.D., Environmental planning, policies & programmes in India, Shipra Publishers, Delhi.
6. Biswas, A.K. and Aggrawal, S.B.C., Environmental Impact Assessment for Developing Countries.

WRE 3.4 G.I.S. LABORATORY			
No. of Periods per week:	L + 3P	Internal Marks:	50
		Univ. Exam. Marks:	50
		Duration of Univ. Exam:	3 Hrs.

Students are supposed to work on various problems involving the following applications using any GIS package.

1. Creation of vector maps and raster maps through digitization and rasterisation
2. Image Processing of digital images (geometric correction, image enhancement, image classification)
3. Preparation of thematic maps (Land use/ land cover, road maps, drainage network map etc.) from satellite image of any region.
4. Watershed delineation from drainage map and contour map of any region.
5. Development of Digital Elevation Model (DEM) using any technique.

WRE 3.5-A CONJUNCTIVE WATER RESOURCES PLANNING			
No. of Periods per week:	4L + 0T	Internal Marks:	30
		Univ. Exam. Marks:	70
		Duration of Univ. Exam:	3 Hrs.

Introduction ; Surface & Groundwater components; System Constraints; Parameter Identification & Model Decomposition; Consumptive water requirement of crops; Conjunctive water use model
Deterministic & Stochastic optimization; Water Quality & Legal aspects; Economic & Multi-objective Analysis

TEXT BOOKS :

1. Goodman, A.S., Principles of water resources planning, Prentice Hall Inc. , New Jercy, 1984.
2. Remson, I., Hornberger, G.M., and Molz. F.J., Numerical methods in subsurface hydrology, Wiley Inter Science.

WRE 3.5-B GROUND WATER FLOW AND CONTAMINANT TRANSPORT			
No. of Periods per week:	4L + 0T	Internal Marks:	30
		Univ. Exam. Marks:	70
		Duration of Univ. Exam:	3 Hrs.

Introduction: Hydrologic cycle, Movement & occurrence of groundwater, properties of groundwater, general flow equations, Dupuit equation

Fundamentals of Groundwater Flow :Occurrence of Ground Water, Vertical Distribution of G.W., Darcy's Law, Permeability, Porosity, Anisotropic Aquifers, Differential equations of G.W. flow.

Potential Flow: Flownets, Boundary conditions, Flow-net construction for confined & unconfined flow systems.
Mechanics of Well Flow: Steady & unsteady flow in confined & unconfined aquifers, Leaky aquifers, Partial penetration of wells, Multiple well systems, Boundary effects & method of images, Well Loses.
Ground Water Modelling: Sand Tank, Heleshaw, Electrical analogous models, Finite Element/Difference models.
Ground Water Development and Management: Design of wells, construction of wells, Well Development, Artificial recharge, Conjunctive use, Salinity of G.W., Ground water pollution.

Sources & type of groundwater contamination, Contaminant transport mechanisms: Advection, Diffusion & dispersion, Mass transport equations, one & two-dimensional modeling

Sorption & other chemical reactions: factors affecting sorption, Sorption isotherms, Sorption effect on fate & transport of pollutants, Estimation of sorption
Biodegradation reactions & kinetics: biological transformations, microbial dynamics, kinetics of biodegradation
Nonaqueous-phase liquids: Types of NAPLs, general processes, NAPL transport computational methods
Groundwater remediation and design: Remedial alternatives, source control, hydraulic controls, bioremediation, soil vapor extraction systems, remediating NAPL sites, emerging technologies

TEXT BOOKS:

1) Rifai & Newell, Ground Water Contamination, Transport and Remediation by Bedient, , PTR Prentice Hall
2) D.K. Todd, Groundwater Hydrology, John Wiley & Sons

REFERENCE BOOKS:

1. M.E. Harr, Groundwater and Seepage.

WRE 3.5-C IRRIGATION WATER SYSTEMS AND MANAGEMENT			
No. of Periods per week:	4L + 0T	Internal Marks:	3
		Univ. Exam. Marks:	70
		Duration of Univ. Exam:	3 Hrs.

Irrigation systems – Major, mini, minor potential surface, lift and GW systems, methods of irrigation, relative merits and demerits, modeling

Soil physics and Soil chemistry; terminology; Soil-water and hydraulic conductivity. Soil chemical properties- impact of soil and water chemical concentrations on yields –management of soil chemical concentrations.
Soil physics and Soil Agriculture, cropping pattern, irrigation, sustainable systems

Planning irrigation systems – crop water requirements, irrigation frequency, yield – Methods of estimation of crop water requirements – methods based on temperature and pan evaporation; combined method; crop coefficient curves.
Surface system design: definitions –furrow system design – level basin system design –graded border system design
Sprinkler System Design: Uniformity and adequacy of water application-evaporation and wind drift-components of system design. Distribution system design and layout- centre pivot system, linear move system- Big gun and Boom sprinkler systems.
Trickle (Drip) irrigation system design: Concept of trickle system- Emitters – flow through laterals – filtration and water treatment systems- fertilizer injection systems.
Water logging and prevention and efficiencies. Optimization techniques in planning as applied to Irrigation.

Agricultural hydrology, subsurface, unsaturated flow, hysterisis, soil moisture and deep percolation, return flows and modeling droughts and mitigation of droughts.

TEXT BOOKS:

1) Chaturvedi,Water Resources Systems Planning and Management , M.C. Tata McGraw Hill
2) James L.D and Lee R.R, Economics of Water Resources Planning, McGraw Hill
3) Maiche,l Irrigation theory & Practise
4) Richard H. Cuenea, Irrigation System Design (An engineering approach), Prentice Hall
5) Deniel P. Louchs, Jerry R. Stedinger and Danglass. A. Haith, Water resources systems planning and analysis , Prentice Hall

REFERENCE BOOKS:

1. Irstelsen and Hanesn, Irrigation – Principles and methods
2. Mays L.W. and Tung Y.K.,Hydrosystems Engineering and Management McGraw Hill, 1992
3. Ossenburgen P.J., Systems analysis for Civil Engineer, John Wiley and Sons, 1984. 6. Publication of NW, Roorkee

WRE 3.6 & WRE4.1 THESIS / DESSERTATION