

CIVIL ENGINEERING DEPARTMENT

M.TECH. WATER RESOURCE

**Course of Study & Scheme of Examination
2016-17**



**Maulana Azad National Institute of Technology,
Bhopal**

SCHEME

M. TECH. IN WATER RESOURCES ENGINEERING

FIRST SEMESTER

Subject Code	Subject Name	Scheme of Studies Periods per week			Total Credit
		L	T	P	
WRE511	Engineering Fluid Mechanics	3	-		3
WRE512	Engineering Hydrology	3	-		3
WRE513	Irrigation and Drainage Engg.	3	-		3
	Elective 1	3	-		3
	Elective 2	3	-		3
	Open Elective1	3	-		3
WRE514	Lab Practice 1	-	-	3	2
WRE515	Seminar 1	-	2	-	2
Total credits					22

SECOND SEMESTER

Subject Code	Subject Name	Scheme of Studies Periods per week			Total Credit
		L	T	P	
WRE521	Hydraulic Structures	3	-		3
WRE522	Water Resources Systems	3	-		3
WRE523	Open Channel Hydraulics	3	-		3
	Elective 3	3	-		3
	Elective 4	3	-		3
	Open Elective 2	3	-		3
WRE524	Lab Practice 2	-	-	3	2
WRE525	Seminar 2	-	2	-	2
Total credits					22

Scheme and Syllabus M.Tech. Water Resource Engineering (BOS dt.21.10.2016)

LIST OF DEPARTMENT ELECTIVES

WRE531 Flood Mitigation and Management	WRE539 Water Resources Project Planning, Economics & Management
WRE532 Water Supply Networks	WRE541 Sediment Transport
WRE533 Geotechnical Investigations in Water Resources Projects	WRE542 Reservoir Planning and Management
WRE534 Integrated Watershed Management	WRE543 Stochastic Hydrology
WRE535 Hydraulic Measurement Systems	WRE544 Soft Computing Techniques in WRE
WRE536 Hydraulic Transient	
WRE537 Ground Water Hydrology	
WRE538 Hydraulic Energy Dissipaters	

LIST OF OPEN ELECTIVES:

WRE551 Probability and Statistical Methods
WRE552 Finite Element Method
WRE553 Geospatial Techniques
WRE554 Hydro Power Engg.
WRE555 Environmental Impact Assessment
WRE556 Rainwater Harvesting
WRE557 Environmental Fluid Mechanics

THIRD SEMESTER

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
WRE611	Major Project Dissertation Phase- I	-	-	-	23
Total credits					23

FOURTH SEMESTER

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
WRE648	Major Project Dissertation Phase- II	-	-	-	23
Total credits					23

SYLLABUS

M.TECH IN WATER RESOURCE ENGINEERING FIRST SEMESTER

WRE511 ENGINEERING FLUID MECHANICS

Fluid statics - pressure variation forces on immersed surface plane as well as curved plane, relative equilibrium; fluid kinematics and fluid dynamics.

Boundary layer theory, Viscous flow, Hydraulic Similitude and Modeling. Turbulent modeling, turbulent flow through pipes, forces on immersed bodies.

References

1. Hydraulics & Fluid Dynamics-P.M.Modi and S.M.Seth, Standard book house, Delhi.
2. Engg. Fluid Mechanics- Garde and Miraj, Gaonkar Scitech Pub, 2010
3. Fluid Mechanics & Hyd.- M/c A.K.Jain, Khanna Publishers
4. Engineering Fluid Mechanics Vol. I.- Narasimhan S., Orient Longman
5. Fluid Mechanics for Hydraulic Engineers- Rouse H., Dover Publications

WRE 512 ENGINEERING HYDROLOGY/ APPLIED HYDROLOGY

Hydrological processes. Budget equation, Precipitation – measurement and analysis of data, Losses measurement and analysis using latest techniques, Runoff estimation and modeling, Hydrograph analysis, Synthetic unit hydrograph. [UH, stream gauging, flood routing]. Design flood, probability of hydrologic events, Linear regression, Hydrologic synthesis and simulation, Ground water.

References

1. Applied Hydrology - Chow V T., McGraw-Hill, Inc.
2. Applied Hydrology- Mutreja K.N, Tata McGraw-Hill. Inc.
3. Engineering Hydrology- Subramanya K, Tata McGraw-Hill.
4. Engineering Hydrology- R.S. Varshney, Nem Chand & Bros.
5. Engineering Hydrology- CSP Ojha, Oxford University Press, USA.

WRE513 IRRIGATION& DRAINAGE ENGINEERING

Crop water requirements, irrigation scheduling, flow and lift irrigation, water application methods, design of surface, sprinkler & drip irrigation systems.

Principles of drainage system, types of drainage, design of surface and subsurface drainage, water logging and salinity control, Design of lined and unlined canals, diversion headworks.

References

1. Irrigation and Water Resources Engineering- G.L. Asawa, New age international Publisher.
2. Irrigation theory and practices - A.M. Michael,Vikas Publishing House Pvt Limited.
3. Irrigation system design – An Engineering Approach :Richard H Cuenca,Prentice Hall.
4. Hand book of Irrigation Technology- H.J. Finkel, Vol.I.
5. Irrigation Structures Vol.I, - IR.S Vashney, Nem Chand & Brothers.

WRE514 LAB PRACTICE 1

Experiments on Fluid mechanics

WRE515 SEMINAR1

SECOND SEMESTER

WRE521 HYDRAULIC STRUCTURES

Types of dams, design of gravity dams, arch and buttress dam, earth & rockfill dam.

Design of spillways and Energy dissipating devices. Design of canal structures, Diversion headworks.

References

1. Design of gravity dams -USBR
2. Design of small dams -USBR
3. Embankment Dam Engineering - Bharay Singh & RS Vashney, Nem Chand & Bros.
4. Irrigation Structures Vol.IIRS - Vashney, Nem Chand & Brothers.
5. Hydraulics of spillways and energy dissipaters- RS Vashney, CRC Press.

WRE522 WATER RESOURCES SYSTEMS

Nature of water resources systems. water resources planning and development.

System analysis techniques in water resources: optimization, linear programming, dynamic programming, simulation. Application of system analysis and optimization techniques to water resources engineering problems.

Economic considerations in water resources systems: basic principles of economics, project feasibility and optimality, cost allocation.

References

1. Water Resources Systems- SubhasChander and Rajesh Prasad, Jain Brothers.
2. Water Resources System Planning and Management- S.K.Jain and V.P.Singh, Elseveir.
3. Water Resources Systems- S. Vedula and P. P. Majumdar, Tata McGraw-Hill Education.
4. Water Resources System Planning and Analysis- D.P.Loucks, J.R.Stedinger, D.A.Haith. Englewood Cliffs, Prentice-Hal.

WRE523 OPEN CHANNEL HYDRAULICS

Basic concepts, uniform flow rigid & non rigid boundary channels, specific energy and critical depth, Gradually varied flow, Rapidly varied flow – Hydraulic jump on horizontal and sloping floor, Brink depth, surges, unsteady flow channel controls and transitions.

References

1. Open Channel Flow - Chaudhary Hanif M., Springer.
2. Flow through open channel- Chow V T., Mc Graw-Hill.
3. Flow in open channels- Subrmanya K, Tata McGraw-Hill Education.
4. Flow through open channel- K.G .Raja, McGraw-Hill.

WRE524 LAB PRACTICE 2

Experiments on Open channel and modeling

WRE525 SEMINAR 2

DEPARTMENT ELECTIVES

WRE531 FLOOD MITIGATION AND MANAGEMENT

Alluvial streams and their hydraulic geometry, bed level variation of alluvial streams, variation in plan form of alluvial streams, analytical models of river morphology, numerical models for morphological studies, flood plain analysis, morphology of some Indian rivers, types and design of protection systems, operational hydrology, reservoir operation for flood control and management, flood damage estimation models, guide lines for planning and design of river training works, planning, design, construction and maintenance of river training works and bank protections for alluvial rivers. application of geo- synthetics in river training works.

References

1. Applied Hydrology- Chow V T, Maidment David R and Mays Larry W., McGraw-Hill.
2. Mechanics of sediment transportation and alluvial streams problems- Garde R J and RangaRaju K G., Taylor & Francis.
3. River Morphology- Garde R J Mays Larry W., NewAgePublishers.
4. Hydraulic Design Handbook- Garde R J ,

WRE532 WATER SUPPLY NETWORKS

Type of distribution systems, parameters in distribution system analysis, interrelationship, formulation of equation. Gravity and rising main, location and design principles. Design and optimization of water distribution system: design - trial and error method of design, cost- head loss ratio method. Optimization using linear programming techniques, surge analysis in water distribution systems, pump duty stations and detailing valves.

References

1. Analysis of Flow in Water Distribution Network- Bhave P R., Technomic Pub. Co.
2. Optimal Design Of Water Distribution Networks- Bhave P R., Alpha Science International.
3. Fluid Transients- Streeter V L and Wylie E D., Prentice Hall.

WRE533 GEOTECHNICAL INVESTIGATIONS IN WATER RESOURCES PROJECTS

Problems and phases of foundation investigations; methods of exploration, geophysical and conventional methods; sounding, drilling and boring technique; ground water table determination; field tests – penetration tests, vane shear tests, pressure meter test, plate load test, field permeability test, critical evaluation of different tests; preservation and transportation of samples; selection of type of laboratory tests, analysis and interpretation of results, site evaluation and reporting. Suitability of soils for different water resources projects, study of various relevant I.S. codes. Application of remote sensing in geotechnical investigation.

References

1. Soil Mechanics & Foundation Engineering- K.R. Arora, Standard Publishers Distributors.
2. Engineering for Embankment Dams- Bhart Singh & R.S. Varshney, Aa Balkema (December 1995).
3. Soil Machines & Foundation Engineering -V.N.S. Murti. CRC Press

WRE534 INTEGRATED WATERSHED MANAGEMENT

Principles of watershed management, soil and water conservation practices, integrated planning, multidisciplinary approach, erosion and soil salinity problems and controlling techniques, gully control, landslide and correction techniques, structural and non structural measures, watershed modeling , application of remote sensing in water resources mapping, area assessment and watershed management, preparation of land drainage scheme, types and design of water conservation and water harvesting structures for different types of catchments

References

1. Watershed management and Field manuals -FAO
2. Watershed Management – Guidelines for Indian conditions :Tideman, E. M.,Omega Scientific

WRE535 HYDRAULIC MEASUREMENT SYSTEMS

General characteristics of a measurement system, measurement system and stages, sensors and transducers, transmitters, converters, input-output relationship of measuring instruments, classification of errors and methods for reducing errors, calibration, sensitivity, hysteresis, resolution, drift, linearization, choice of instrument for a specific application. mechanical

pressure sensors, electrical pressure measuring devices, pressure transmitters and vacuum measurement systems. variable head flow meters, variable area flow meters, positive displacement flow meters, hot wire anemometer, open channel flow meters, mass flow measurement, liquid level, solid level and continuous level measurement. elastic elements for force measurement, torque measurements, electrical resistance.

References

1. Instrumentation, Analysis and Measurement- Nakra and Choudhary, Tata McGraw-Hill Education
2. Industrial Instruments - A.L. Seutko, Thomas Delmer, Newnes Publishing.
3. Measurement and Instrumentation Systems - W. Bolton Newnes, Newnes Publishing.

WRE536 HYDRAULIC TRANSIENTS

Flow oscillation in U tubes, Time of Establishment of flow.

Water Hammer: phenomenon, equations for elastic waves in simple and complex conduits, arithmetic integration and graphical methods of solution, Differential equations of water hammer and solution by method of characteristics.

Reflection and transmission of water hammer waves.

Allievi's equations and charts for uniform valve closure

Unsteady flow in canals: General differential equations of motion and continuity, shallow water equations and their solution using method of characteristics.

Surge Tanks: Functions, Different types, Design of surge tanks- Calame-Gaden equations, Johnsons method. Stability of surge tanks

References

1. Applied Hydraulic Transients- M. Hanif Choudhary Van Nostrand Reinhold, Springer
2. Hydraulic Transients- Streeter, McGraw-Hill.
3. Water Power Engineering- M.M. Desmukh, Dhanpat Rai Pub.

WRE537 GROUND WATER HYDROLOGY

Introduction : occurrence of ground water, geological formations as aquifers; types of aquifers, ground water movement, Darcy's law, permeability and its measurement, tracing of ground water movement, fundamental equations for steady and unsteady ground water flow, flow nets. well hydraulics: steady and unsteady flow in confined, semi-confined and unconfined aquifers, radial flow, superposition; multiple well system. Different methods of well construction; construction of well casings and screens, natural and artificial gravel packed wells. safe yields, estimation, pumping and recuperation tests. infiltration galleries, ground-water recharge, different methods. Groundwater modeling techniques: porous media models, analog models, electric analog models, digital computer models. Seawater intrusion: concept; interface and its location; control of intrusion. pollutant transport ; plume transport, source identification, tracer methods.

References

1. Groundwater Hydrology - David Keith Todd, Wiley.
2. Hydraulics of Groundwater - Jacob and Bear McGraw-Hill International Book Co.
3. Applied Hydrology- Mutreja K.N., Tata McGraw-Hill, 1990.
4. Groundwater & Well Hydraulics- Raghunath, New Age International.

WRE538 HYDRAULIC ENERGY DISSIPATORS

Introduction, mechanism & types of energy dissipators, hydraulic jump, outlet works control mechanism, stilling basins for small outlet works and low and medium-high spillways , Various aspects of stilling basins, types of stilling basins and different appurtenances.

References

1. Hydraulic Energy Dissipators - Edward A. Elevatorski, McGraw-Hill, 1959.
2. Energy Dissipators and Hydraulic Jump-W.H.Hager, Springer.

WRE539 WATER RESOURCES PROJECT PLANNING, ECONOMICS & MANAGEMENT

Principles of economic planning and decision making, price theory and resource allocation- Project Optimality conditions, cost- benefit studies: role of benefit-cost parameter in project selection. Economic feasibility tests. Involvement of risk and other variables, tangible and intangible benefits; Cost-benefit studies of single and multipurpose water resources projects;

Economic planning: Capacity expansion and project scheduling, multi-objective planning models, international developments on water transfer, preparation of feasibility reports.

References

1. Principles Of Water Resources Planning- Alvin.S.Goodman,Prentice-Hall, 1984.
2. Economic of Water Resources Planning- James L. D. and Lee R. R., McGraw-Hill.

WRE541 SEDIMENT TRANSPORT

Nature of sediment problems, Origin and formation of sediments, individual and bulk properties of sediments, competent velocity, lift force and critical tractive stress concept on cohesion less and cohesive soils; regimes of flow; Resistance to flow in alluvial streams, resistance relations based on total resistance and division of resistance into grain and form resistance, preparation of stage discharge curves for alluvial streams, velocity distribution in alluvial channel, Bed load computation by empirical equations, dimensional considerations and semi-theoretical equations, siltation, Mechanism of suspension, general equations of diffusion. Integration of sediment distribution equation. Differences between actual and theoretical exponents, prediction of reference concentration, Method of integrating curves of concentration and velocity. Simple relations for suspended load, Effect of temperature on suspended load, Wash load, Non-equilibrium transport of suspended load, Microscopic, macroscopic methods. Approximate methods of total load determination, sediment yield from catchments. Hydraulic geometry of alluvial streams, bed level variation of alluvial streams, aggradations and degradation models, reservoir sedimentation, local scours.

References

1. River Mechanics” Vol. I & II- Hsieh Wen Shen, Water Resources Publication.
2. Mechanics of sediment transportation and alluvial stream problems- Garde R. J. and RangaRaju K. G.,Taylor & Francis, 2000.
3. River morphology- Garde R. J.,New age international publisher.
4. Loose boundary hydraulics- Raudkivi, A. J., CRC Press.

WRE542 RESERVOIR SEDIMENTATION MANAGEMENT

Physical process of reservoir sedimentation, siltation mechanism, modes of sediments transport to reservoirs, morphological effects of river impoundment, movement of sediments in reservoirs. Prediction of reservoir sedimentation, storage recovery and preservation. Impact of reservoir sedimentation. Methods for minimizing sediment deposition in reservoir, methods of preserving reservoir capacity and prevention of sediment inflow. Sustainable management of dams for sediment control. Reservoir conservation model, RESCON for technical and economical optimization of reservoir sedimentation studies.

References:

1. Reservoir sediments management- SahnazTigrek and tuce Aras, CRC press.
2. Reservoir sedimentation Handbook- Gregory L. Morris, Jiahua Fan.

WRE543 STOCHASTIC HYDROLOGY

Statistical methods in hydrology, probability distribution of hydrologic variables, hypothesis testing and goodness of fit, flood frequency analysis, single and multiple regression analysis, classification of time series, characteristics of hydrologic time series, statistical principles and techniques for hydrologic time series modeling, time series modeling of annual and periodic hydrologic time series (including AR, ARMA, ARIMA, and DARMA models), multivariate modeling of hydrologic time series, practical considerations in time series modeling applications, Soft computing techniques.

References

1. Stochastic Hydrology - P.Jayrami Reddy, Laxmi Publications.
2. Applied Stochastic Hydrology -Y.K. Zhang

WRE544 SOFT COMPUTING TECHNIQUES IN WRE

Introduction, need for soft computing techniques, components of soft computing. Artificial Neural Networks (ANN), types of ANN and learning algorithms, tasks performed by ANN.

Basic concepts of feed forward neural networks, perception learning rule, back propagation learning algorithm, application of feed forward ANN for function approximation and prediction.

Hebbian learning and hopified networks , pattern association, radial basis function networks, Kohonen networks and self organization maps, applications of ANN in pattern classification.

Information and uncertainty, chance versus ambiguity, classical sets and fuzzy sets, logic and reasoning. Fuzzy set operations and fuzzy relations, Membership Functions, fuzzy numbers and fuzzy arithmetic.

Fuzzy Systems, fuzzy relations, fuzzy interface systems, Decision making with fuzzy information, Fuzzy classification and pattern recognition, Neuro-Fuzzy Systems.

Evolutionary computing , concepts of genetic algorithm, components of genetic algorithm, Hybrid soft computing techniques, Applications in Hydrology and Water Resources Engineering.

References

1. Neural Networks, A Comprehensive Foundation- Haykin, Prentice Hall India.
2. Neuro-Fuzzy and Soft Computing A Computational Approach to learning-Jang, J.R., Sun Chuen-tsai and Mizutani Eiji, Prentice Hall.

OPEN ELECTIVES

WRE 551 PROBABILITY AND STATISTICAL METHODS

One dimensional random variables: Random variables - Probability function – moments – moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Functions of a Random Variable, weighting of observations.

Two dimensional random variables: Joint distributions– Marginal and Conditional distributions – Functions of two dimensional random variables – Curve fitting– Regression Curve – Correlation., Propagation of systematic and accidental errors, theory of least squares and its application to adjustment problems.

Statistical principles and techniques for hydrologic time series modeling, time series modeling of annual and periodic time series (including AR, ARMA, ARIMA, and DARMA models), multivariate modeling of time series, practical considerations in time series modeling applications,

Testing of hypotheses, Covariance matrix – Correlation Matrix – Multivariate Normal density function Principal components – Sample variation by principal components – Principal components by graphing. Multivariate analysis Sampling distributions - Type I and Type II

errors - Tests based on Normal, t, Chi-square and F distributions for testing of mean, variance and proportions – Tests for Independence of attributes and Goodness of fit.

References

1. Probability & statistics for Engineering and the Sciences- Jay L. Devore, Cengage Learning, Inc.
2. Applied multivariate methods for data analysis- Dallas E Johnson, Duxbury Resource Center.
3. Probability and Statistics for Engineers- Richard Johnson, Pearson.
4. Applied Multivariate Statistical Analysis- Richard A. Johnson and Dean W. Wichern, Pearson.

WRE552 FINITE ELEMENT METHOD

Basic concepts of mathematical models and numerical simulation, Initial and boundary value problems, classification of partial differential equations, flow governing equations applied to water resources, features and steps of FEM analysis, weak formulation, Ritz method, weighted residual methods, discretisation of domain, coordinate systems, interpolation functions, element matrix, assembly of element matrices, application of boundary conditions, solution of algebraic equations, numerical integration, parametric formulations, serendipity elements, Jacobian, application of FEM to simple discrete system and continuous domain problems of water resources

References

1. An Introduction to The Finite Element Method- Reddy J.N., McGraw-Hill.
2. Finite Element Analysis- Theory and Programming- C.S. Krishnamoorthy, Tata McGraw-Hill Education.
3. Finite Element Handbook-H. Kardestuncer

WRE553 GEOSPATIAL TECHNIQUES

Introduction to Geospatial Technologies. Usefulness in Water Resources Engineering. Fundamentals of remote sensing - Interpretation - Equipments - Techniques of data acquisition – Satellites and sensors – Digital Image processing. Introduction to GPS - Working principle of GPS - Measurement and mapping techniques Introduction - Geo referenced data - Data input

& output - Data quality and management - GIS analysis functions - Implementation of GIS. Geospatial Analysis-Methods -Measurements - Analysis – Geo visualization, Different geospatial technology software - Salient features – Capabilities. Application of Geospatial Technologies to Water resources Engineering - Case studies

References

1. Essentials of GPS- Agrawal N.K.,Printsasia
2. Remote Sensing and GIS- Bhatta B., Oxford University Press.
3. Remote Sensing and Image Interpretation- Lillesand T.M. and Kiefer R. Wiley
4. Geographical Information Systems - Stan Aronoff,WDL Publications

WRE554 HYDRO POWER ENGINEERING

Need of hydropower, planning for water power development, estimation of available water power, power duration curve, storage and pond age, load power load factor, load duration curve, classification of hydropower development, economics of hydropower development. operation and maintenance of hydro plants. Components of storage power development, run-off-river power development and pumped storage power plant (PSPP). advantages, types and location of underground power station, its components, types of layout, limitations of underground power plants, advantages of small hydropower, classification of small hydropower, , components of small hydropower development, economics of small hydropower schemes. general layout of the power house and arrangement of hydropower units, variation in design of power house. under ground power station: types of underground power plants, alignment and layout of cavities, investigations and studies, safety requirements, sizing of a power house, types, location and alignment of intakes, losses in intakes. hydraulic design of penstocks, valves and gates.

References

1. Water Power Engineering- Barrows H. K.,McGraw-Hill Book.
2. Water Power Engineering- Dandekar and Sharma,Vikaspublishing.
3. Water Power Engineering - Deshmukh M.M.,Dhanpatrai sons.
4. Handbook of Hydroelectric Engineering- Nigam P S.

WRE555 ENVIRONMENTAL IMPACT ASSESSMENT

EIA as a tool for sustainable development, concept of carrying capacity in terms of supportive and assimilative capacities, food security issues and significance and uses of multipurpose water resources projects impact assessment: environmental, social and economic issues, issues in collection of baseline data, concept of scoping, screening, environmental impact assessment (EIA), and environmental impact statement (EIS), rapid and comprehensive EIA, methodologies: including checklists, matrices and networks, procedures for environmental clearance by the government of India with reference to water resources projects, history of irrigation related environmental impacts across civilizations, impact of water resources projects on environment, large dams versus small dams: issues and controversies. green revolution and its consequences, case studies relating to large multi-purpose water resources projects, mitigation strategies specific to water resources projects, environmental management, appropriate sitting practices to minimize environmental damages, and rehabilitation issues, rehabilitation policies of the government of India.

References

- 1 Introduction To Environmental Impact Assessment- John Glasson, Riki Therivel, Routledge,
2. Methods Of Environmental Impact Assessment - Peter Morris, Riki Therivel, Taylor & Francis
3. Environmental Impact Assessment, Theory And Practice-Peter Wathern , Routledge

WRE556 RAINWATER HARVESTING

Concepts of Water Shed need for watershed development in India, Planning of watershed management. Drainage. Need for artificial recharge and rain water harvesting. Recharge Structures: various artificial recharge structures: recharge ponds - recharge pits - percolation ponds - Rainwater harvesting in urban areas: RWH structures - design - construction. Recharge Estimation & Maintenance: Estimation of probable runoff from an area including roof tops - maintenance and monitoring of RWH structures Exploration techniques and selection of artificial recharge zones

References

1. Groundwater Hydrology- David Keith Todd, Wiley.
2. Rainwater Harvesting Techniques to augment Groundwater- Ministry of Water Resources,
3. Groundwater and Wells - Edward E. Johnson S.I.,

WRE557 ENVIRONMENTAL FLUID MECHANICS

Introduction: The role of fluid mechanics in environmental planning, Transport of substances in the hydrologic cycle, Protection of water quality Basic Relationships: Conservation of mass, energy and momentum, Law of fluid motion - Navier-Stokes equations -Turbulent flow, Diffusion process Heat and Mass Transfer: Diffusive transport of substances (molecular diffusion), Heat transfer equations, Relationships Turbulence: Properties of turbulent flow, Basic equations of turbulent momentum transport, Turbulent hypothesis, Dispersion Stratification and Density Driven Flow: Density variations in fluids, Stability and stratification (hydrostatics, hydrodynamics), Stratified flow examples Jets and Plumes: similarity theory, entrainment hypothesis, applications for different environmental conditions and source configurations Emission Standards for Sewage and Heat Discharges; Flow, transport and mixing Process in lakes, Reservoirs and rivers Water Quality Standards: River and estuarine water quality models (model formulation, dimensionality, applications), Integrated Water Quality management

References:

1. Fluid Mechanics- Liggett, J.A., McGraw Hill International, Singapore.
2. Fluid Mechanics for Chemical Engineers- Wilkes, J.O., Prentice Hall, Englewood Cliffs
3. Fluid Mechanics - Douglas, J.F., Gasiorek, J.M. and Swaffield, J.A., Addison Wesley, Reading
4. Fluid Mechanics - Streeter, V.L., Wylie, E.B. and Bedford, K.W., WCB/McGraw-Hill
5. Applied Fluid Mechanics - Papanastasiou, T.C., Prentice-Hall.
6. Fundamentals of Fluid Mechanics- Gerhart, P.M., Gross, R.J. and Hochstein, J.I., Addison Wesley, Reading.
7. Fluid mechanics of Atmosphere- Brown, R.A., Academic Press.
8. Process Fluid Mechanics - Denn, M.M., Prentice Hall, Englewood Cliffs.