VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
CHOISE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2016 -17
M.Tech. WATER AND LAND MANAGEMENT

I Semester

SL No.	Subject Code	Title	Teaching Hours/Week		Examination			Total Marks	Credit
			Lecture	Practical / Field Work/ Assignment	Duration (Hours)	I.A Marks	Theory/Practical Marks		
1	16WLM11	Optimization Techniques	4	-	3	20	80	100	4
2	16WLM12	Surface Water Hydrology	4	-	3	20	80	100	4
3	16WLM13	Water Pollution Control	4	-	3	20	80	100	4
4	16WLM14	Remote Sensing & GIS	4	-	3	20	80	100	4
5	16WLM15X	Elective – 1	3	-	3	20	80	100	3
6	16WLML16	Environmental Engineering-Laboratory	-	3*	3	20	80	100	2
7	16WLM17	Seminar	-	3	-	100	-	100	1
Total			19	6	18	**220**	**480**	**700**	**22**

* (2Hrs Lab+1 Hrs Instruction)

Elective – 1	
16WLM151	Design of Hydraulic Structures
16WLM152	Spatial Planning and Regional Analysis
16WLM153	Water Treatment Technology & Management
16WLM154	Advanced Remote Sensing

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II Semester

SL No.	Subject Code	Title	Teaching Hours/Week		Examination			Total Marks	Credits
			Lecture	Practical / Field Work/ Assignment	Duration (Hours)	I.A Marks	Theory/Practical Marks		
1	16WLM21	Watershed Management	4	-	3	20	80	100	4
2	16WLM22	Solid Waste Engineering & Management	4	-	3	20	80	100	4
3	16WLM23	Advanced Irrigation Engineering	4	-	3	20	80	100	4
4	16WLM24	Groundwater Hydrology	4	-	3	20	80	100	4
5	16WLM25X	Elective – 2	3	-	3	20	80	100	3
6	16WLML26	Computational-Laboratory	-	3*	3	20	80	100	2
7	16WLM27	Seminar	-	3	-	100	-	100	1
Total			19	6	18	**220**	**480**	**700**	**22**

*(2Hrs Lab+1 Hrs Instruction)

Elective – 2	
16WLM251	Urban Flood Management
16WLM252	Wastewater Engineering & Management
16WLM253	Ground Improvement Technique
16WLM254	Water Quality Modeling & Management

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III Semester: INTERNSHIP

Sl No.	Subject Code	Title	Teaching Hours/Week		Examination			Total Marks	Credits
			Lecture	Practical / Field Work/ Assignment	Duration (Hours)	I.A Marks	Theory/Practical Marks		
1	16WLM31	Seminar/ Presentation on Internship (After 8 weeks from the date of commencement)	-	-	-	25	-	25	20
2	16WLM32	Report on Internship	-	-	-	25	-	25	
3	16WLM33	Evaluation and Viva-Voce of Internship	-	-	-	-	50	50	
4	16WLM34	Evaluation of Project Phase-1	-	-	-	50	-	50	1
Total			-	-	-	**100**	**50**	**150**	**21**

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IV Semester

Sl No.	Subject Code	Title	Teaching Hours/Week		Examination			Total Marks	Credits
			Lecture	Practical / Field Work/ Assignment	Duration (Hours)	I.A Marks	Theory/Practical Marks		
1	16WLM41	Environmental Impact Assessment	4	-	3	20	80	100	4
2	16WLM42X	Elective – 3	3	-	3	20	80	100	3
3	16WLM43	Evaluation of Project Phase-2	-	6	-	50	-	50	3
4	16WLM44	Evaluation of Project and Viva-Voce	-	-	-	-	100+100	200	10
Total			7	-	6	**90**	**360**	**450**	**20**

Elective – 3	
16WLM421	Wetland management
16WLM422	Groundwater Assessment, Development & Management
16WLM423	Industrial Waste Management & Audit
16WLM424	Global Warming and Climate Change

Note:

1. Project Phase-1: 6-week duration shall be carried out between 2nd and 3rd semester vacations. Candidates in consultation with the guide shall carry out literature survey/visit industries to finalize the topic of project.
2. Project Phase-2: 16-week duration during 4th semester. Evaluation shall be done by the committee constituted comprising of HOD as chairman, guide and senior faculty of the department.
3. Project Evaluation: Evaluation shall be taken up at the end of 4th semester. Project work evaluation and viva-voce examination shall be conducted,
4. Project Evaluation:
   a. Internal examiner shall carryout the evaluation for 100 marks.
   b. External examiner shall carry out the evaluation for 100 marks.
   c. The average of marks allotted by the internal and external examiner shall be the final marks of the project evaluation.
   d. Viva-Voce examination of project work shall be conducted jointly by internal and external examiner for 100 marks.

OPTIMIZATION TECHNIQUES

[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLM11	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives:

- To understand history & development of optimization concepts
- To formulate Linear and dynamic programming for real world problems
- To understand different optimization techniques available for obtaining solution for real world problems
- To find optimized solutions for transportation and assignment problems
- To learn simulation and advanced optimization techniques

Modules	**Teaching Hours**
Module -1	
INTRODUCTION Development of optimization techniques, nature and characteristics of operation research, methodology of optimization, applications of optimization techniques, classification of operation research model, uses and limitation of optimization techniques.	**10 Hours**
Module -2	
LINEAR AND DYNAMIC PROGRAMMING Introduction to operations research - Linear programming, problem formulation, graphical solution, solution by simplex method - Sensitivity analysis, application to design and operation of reservoir, single and multipurpose development plans - Case studies. Dynamic programming-Stage coach problem to resource allocation, distribution of efforts problem. Optimization by simulation, mathematical models for large scale Multipurpose projects, different case studies.	**10 Hours**
Module -3	
TRANSPORTATION PROBLEM Transportation problem, mathematical formulation of problem, steps in transportation method, methods for finding initial basic feasible solution, degeneracy in transportation problem. **ASSIGNMENT PROBLEMS** Mathematical formulation, assignment algorithm methods for solving assignment problems. Network problems.	**10 Hours**
Module -4	
SIMULATION Basic principles and concepts - Random variant and random process - Monte Carlo techniques - Model development - Inputs and outputs - Single and multipurpose reservoir simulation models - Case studies.	**10 Hours**
Module -5	
ADVANCED OPTIMIZATION TECHNIQUES Integer and parametric linear programming - Goal programming models with applications. Discrete differential dynamic programming and incremental dynamic programming - Linear decision rule models with application - Stochastic dynamic	**10 Hours**

programming models	

Course outcomes: At the end of the course the student will be able to:

- Explain history & development of optimization concepts
- Formulate Linear and dynamic programming for real world problems
- Apply different optimization techniques available for obtaining solution for real world problems
- Find optimized solutions for transportation and assignment problems
- Apply advanced optimization techniques for solving present problems related to water and land management

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Reference Books:

1. H.A. Taha: "Operations Research" Macmilan Publishing Co.
2. S.D. Sharma: "Operations Research" KedaranathRamnath& Co. Meerut.
3. Ravindran,D.T.,Philips and Solberg,J.J. "Operation Research- Principles and practice"
4. KantiSwarup, P.K. Gupta &Manmohan "Operations Research" Sultan chand & sons.
5. Hadly,G. "Linear programming"
6. Rao,S.S., "Engineering Optimization",
7. Arora, J.S., Elservier, 2nd Edition "Introduction to optimum Design"-(2004),.
8. Hiller,F.S., and Liberman,G.J., "Introduction to operation Research"-(1992), CBS publication and Distributions, New Delhi.

SURFACE WATER HYDROLOGY

[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLM12	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives:

- To Analyze components of hydrologic cycle
- To Predict hydrologic extreme events for hydraulic and hydrologic design
- To Develop forecasting models for operation of hydrologic systems
- To Assess surface water resources

Modules	Teaching Hours
Module -1 Introduction: Scope and importance of hydrology, Hydrologic cycle, Global and India's Water resources, Applications of hydrology. Watershed concept and modeling: Catchment-topographic and ground water divide, stream patterns, Description of the catchment, catchment processes, demarking a catchment, water budgeting, Classification of models, model formulation, Lumped parameter conceptual models, Physically based models, Model performance testing. Precipitation:-Transitory systems favoring precipitation, Formation of precipitation, Climate and Weather seasons in India.	**10 Hours**

Module -2	
Location of rain-gauges and optimum number of rain-gauges, Analysis of rainfall data, Rainfall mass curve and hyetograph, Intensity-Duration analysis, Intensity-Frequency-Duration analysis, Depth-Area-Duration analysis, Double mass curve. Abstractions from precipitation: Evaporation-Process, measurement, empirical equations and Estimation by water budget method and Energy budget method.	**10 Hours**
Module -3	
Evapo-transpiration-AET & PET, Estimation by Penman's equation, Reference Crop Evapo-transpiration by Blaney Criddle formula, Infiltration-Process, Measurement, Horton's equation and Philip's equation. Infiltration indices, measurement factor affecting infiltration. Probability and Statistics-Introduction, Probability and Random variables, PDF and CDF, Distribution functions, Selection of distribution function and its parameter estimation. Correlation, Regression analysis-Simple linear and multiple linear regression, curvilinear regression. F test and t- tests. Runoff:-Process, Factors affecting runoff, API, Basin yield, Curve number method.	**10 Hours**
Module -4	
Hydrograph and its features, hydrograph separation methods, Unit hydrograph and its derivation, Unit hydrographs from complex storms and for various durations, Use of S curve, Synthetic unit hydrograph.	**10 Hours**
Module -5	
Flood: Design flood and its estimation- Rational method, Frequency analysis Gumbel's and Log-Pearson's type III distribution, Risk and Reliability, Flood routing- Reservoir routing: Modified Pul's method, Goodrich method, Channel routing- Prism and Wedge storage, Muskingum method, Flood control- Structural and Non-structural measures.	**10 Hours**

Course outcomes: At the end of the course the student will be able to:

- Analyze components of hydrologic cycle
- Predict hydrologic extreme events for hydraulic and hydrologic design
- Develop forecasting models for operation of hydrologic systems
- Assess surface water resources

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Reference Books:

1. Linsley R K, Kohler and Paulhus, "Hydrology for Engineers", McGraw Hill, NY, USA,1958.
2. Mutreja, K. N., "Applied hydrology", Tata McGraw Hill Pub. Co., New Delhi, India-1986.
3. Chow, V.T., "Handbook of Applied hydrology", McGraw Hill, NY, 1964
4. Singh, V. P., "Elementary Hydrology", Prentice Hall, 1992
5. Subramanya K., "Engineering Hydrology", Tata McGraw Hill, 1998
6. Jaya Rami Reddy, P., "A text book of Hydrology", Laxmi publications,2009
7. Putty, M. R.Y., "Principles of Hydrology", I.K. Int. Publishing House, New Delhi,2010

WATER POLLUTION CONTROL

[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLM13	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: The course is designed to train students:

- To have thorough knowledge of Water Acts,
- Effects of Industrial waste on water and land,
- Sources and estimation of point and non point sources of pollution.

Modules	**Teaching Hours**
Module -1 **Introduction**: Definition of Water Pollution, Cause and Sources and Consequences of Water Pollution, Water Act (1986), National Water Policy (CPCB). **Industrial Waste Effects**: On Sewage Treatment Plant and Receiving Water Bodies, River and Lake Water Pollution due to Waste Waters Discharge and Self Purification of Streams. Streeter-Pheliphs Formulation. Effluent Standards and Stream Standards. Material balance calculations as applied to river water quality studies. Problems on Streeter-Pheliphs formulation.	**10 Hours**
Module -2	
Water and Waste: Material balance-methods of qualifications, Sampling: Grab Composite and Integrated Samples. Estimating unit loadings from point and non-point sources. Continuous Monitoring: pH, Conducting and Bio-monitoring. Problems on Material Balance. Surface and Ground Water quality monitoring, Water pollution, Sources of pollution, Nature of pollutants, Existing approaches of control/abatement of water quality degradation, Water quality monitoring in river basins.	**10 Hours**
Module -3	
Point and Non-Point Source of Pollution: Surface and Ground Water quality modeling – Modeling and Monitoring, evaluation of water quality models, types of water quality models, DO and BOD in streams, Transformation and transport processes, Oxygen transfer, Turbulent mixing, Non – Point source pollution, Modeling approaches for modeling non – point sources. Water quality objectives and standards, Water quality control models, Flow augmentation, Waste water transport systems, River and lake water quality models, Groundwater quality models, Wastewater transport systems Water Quality Management in rivers, streams, and other water bodies.	**10 Hours**
Module -4	
Geo-environmental Issues and management Soil mineralogy characterization and its significance in determining soil behavior – soil-water interaction and concepts of double layer – forces of interaction between soil particles. Concepts of unsaturated soil – importance of unsaturated soil in geo-environmental problems - measurement of soil suction - water retention curves - water flow in saturated and unsaturated zone.	**10 Hours**

Soil-water-contaminant interactions and its implications – Factors effecting retention and transport of contaminants. Water law – riparian rights, Groundwater ownership, Prior appropriation, Permit systems, acquisition and use of rights, Uncertainty concepts in Water Resources Planning - methods for uncertainty analysis and applications. Environmental Protection Law, Water pollution control acts and legislation, Legislation in India, Control Acts.	
Module -5	
Characterization of Water Pollutants: Nuclear Power Plants, Thermal Power Plants, Industries: Fertilizer, Tannery, Pulp, and Paper Mill and Pharma- Canticle Industries	**10 Hours**

Course outcomes:

On completion of this course, students are able to

- Understand Water Acts
- Evaluate the Impact of industrial waste effects
- Understand the various sources of pollution and its effects
- Estimate Point and non point sources of pollution

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Reference Books:

1. Metcalf and Eddy, A Text Book of Waste Water Engineering
2. Peavey Rowe and Techobonoglous, Text Book of Environmental Engineering, Mcgrow-Hill International Edition.
3. Hillel D., "Introduction to Soil Physics" Academic Press, New York, 1982.
4. Sparks, D.L., "Environmental Soil Chemistry" Academic Press, New York, 2002.
5. Bagchi, A., "Design of landfills and integrated solid waste management" John Wiley & Sons, Inc., USA, 2004.
6. Alvarez-Benedi J. and Munoz-Carpena, R., "Soil-Water-Solute Process Characterization: An Integrated Approach" CRC Press, New York, 2005.
7. Berkowitz, B. Dror, I. and Yaron, B., "Contaminant Geochemistry" Springer, Germany, 2008.
8. Sharma H.D. and Reddy K.R., "Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies" John Wiley & Sons, Inc., USA, 2004.

REMOTE SENSING & GEOGRAPHICAL INFORMATION SYSTEM
[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLM14	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: Students will be able to know

- The principles of Remote Sensing and GIS
- To develop spatial database for its various application
- To perform various spatial analysis related to water and land management

Modules	Teaching Hours
Module -1 **1. Remote Sensing:** **Introduction:** Types of remote sensing with respect to wavelength regions; active and passive remote sensing. Platforms: Types of platforms - airborne remote sensing, space borne remote sensing; Atmospheric condition and altitude; Attitude of platform. **Physics of Remote Sensing**: Electromagnetic spectrum, Characteristics of electro-magnetic radiation; Interactions between matter and electro - magnetic radiation; Wavelength regions of electro - magnetic radiation. Black body radiation; Reflectance; spectral reflectance of land covers; Spectral characteristics of solar radiation; energy interaction in the atmosphere; energy interactions with the earth's surface -spectral reflectance curves.	**10 Hours**
Module -2	
Image Interpretation and Analysis: Remote sensing data formats; Techniques of visual interpretation. **Digital Image Processing:** Digital data manipulation and analysis; image rectification – Radiometric correction, Atmospheric correction, Geometric correction; image enhancement –Spatial feature manipulation and multi- image manipulation; classification techniques– Supervised classification and unsupervised classification.	**10 Hours**
Module -3	
2. Geographical Information System: **Introduction to GIS:** Introduction to GIS History of GIS, Early developments in GIS, Applications of GIS, Spatial Data Input and Editing: Primary Data, Secondary Data, And Data Editing **Geo-referencing and Projection:** Understanding Earth, Coordinate System, Map Projection, Transformation, Geo-referencing	**10 Hours**
Module -4	
Spatial Database Management Systems: Introduction, Data Storage, Database Structure Models, Database Management system, Entity Relationship Model, Normalization. **Data Models and Data Structures:** Introduction, GIS Data Model, Vector Data Structure, Raster Data structure	**10 Hours**
Module -5	
Spatial Analysis: Introduction to spatial analysis, Vector Operations and Analysis, Network Analysis, Raster Data Spatial Analysis. **Interpolation:** Introduction to Interpolation, Global Methods of Interpolation, Local Methods of Interpolation	**10 Hours**
Course outcomes: On completion of this course, students are able to	

- Develop a sound understanding of the principles and function of Remote Sensing & GIS.
- Understand various techniques in preparing spatial data.
- Understand various spatial analysis to manage water and land

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Reference Books:

1. Kang-Tsung Chang, 'Introduction to Geographic Information Systems', McGraw-Hill Book Company.
2. M. Anji Reddy, 'Remote Sensing and Geographical Information Systems' 4th Edition, BS Publications.
3. Longley, P. A., Goodchild, M. F., Maguire, D. J., and Rhind, D. W., 'Geographic Information Systems and Science', 2nd Edition, John Wiley and Sons.
4. Burrough, P. A., and McDonnell, R. A. 'Principles of Geographical Information Systems', Oxford University Press, 2nd Edition.
5. Demers, M. N., 'Fundamentals of Geographic Information Systems', John Wiley & Sons, 3rd Edition.

DESIGN OF HYDRAULIC STRUCTURES

[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLM151	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 03

Course objectives:

- To explain the factors governing site selection for construction of different hydraulic structures and procedure for report/documentation;
- To estimate forces to be considered for design of hydraulic structures like gravity dam, earth dam, diversion structures, regulators, canals;
- To analyze & design different hydraulic structures like dam, regulator, and canal.

Modules	Teaching Hours
Module -1 **Introduction:** Major/Medium/Minor irrigation projects, factors governing selection of type of dam, preliminary investigation for hydraulic structures sites, preparation o reports. **Gravity Dam:** Principle stresses, Modes of failure, stability analysis, high/low dam, elementary/ practical profile, gravity & zonal method design.	**08 Hours**
Module -2	
Earthen Dam: Types, general principles of design, causes of failure, analysis of seepage through earth dams, stability analysis, control of seepage.	**08 Hours**
Module -3	
Spillway: Types, design criteria (ogee), energy dissipaters **Diversion Structures:** Types, causes of failure, Bligh's Theory and Khosla's Theory,	**08 Hours**

Design of Vertical Drop Weir.	
Module -4	
Diversion Structures continued: Design of Vertical Drop Weir. **Regulators**: Functions of cross/head regulator, alignment, Design of Cross Regulators.	**08 Hours**
Module -5	
Canal System: Canal networks, Kennedy's and Lacey's theory of canal design, Introduction to Canal fall and Canal Escapes.	**08 Hours**

Course outcomes:

- Judge suitable sites for locating different hydraulic structures;
- Estimate forces to be considered for design of hydraulic structures;
- Analyze & design different hydraulic structures like dam, regulator, and canal.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Reference Books:-

1. Modi, P.N. "Irrigation, Water Resources and Water Power Engineering" Standard Book House, New Delhi, 2nd ed, 1990.
2. Varshney "Concrete dams"— Oxford & IBH Publications, 1978
3. Creager, Justin, Hinds. "Engineering for Dams (Volume-I, II and III)" – Wiley India Publications.
4. Garg S.K, Irrigation Engineering and Hydraulic Structures, Khanna Publishers N.D. 2006.

SPATIAL PLANNING AND REGIONAL ANALYSIS

[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLM152	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 03

Course objectives:

- To explain the spatial planning-its types, functions and dimensions
- To illustrate the methodology used in spatial planning
- To explain the regional planning and analysis especially for developing countries

Modules	**Teaching Hours**
Module -1 **Introduction to Spatial Planning**: Variants of Planning and Non-Planning, Planning as a Dialogue, Epistemic, Pragmatic an Planning Cycle, Planning Cycle with Internal Selection, Functions of Planning Agencies, Classical Planning Processes, Dimensions of Planning Process:-Organization, Location, Purpose, Openness, Time Horizon, Scope, Specificity, Flexibility	**08 Hours**
Module -2	
Introduction to Spatial Planning: Variants of Planning and Non-Planning, Planning as a Dialogue, Epistemic, Pragmatic an Planning Cycle, Planning Cycle with Internal Selection, Functions of Planning Agencies, Classical Planning Processes, Dimensions of	**08 Hours**

Planning Process:-Organization, Location, Purpose, Openness, Time Horizon, Scope, Specificity, Flexibility	
Module -3	
Regional Planning: Workshop Task(Producers)- Motivation, Information, Organization, Installation, Platform Task(Moderator)- Communication, Concentration, Synchronization, Turntable Task(Mediator)- Articulation, Interpretation, Lookout Task(Observer)- Updating, Reviewing and Alerting, Creative use of Planning Process-Plural, Situational Rational and Involvement, Policy Maker and Citizen Input into the Classical Planning Process:- Ideal Sequence, Shortcut and Recycling within Planning Process.	**08 Hours**
Module -4	
Regional Analysis: Fields of Regional Analysis, Spatial Units and Dimensions, Analysis of Population Change, Economic Analysis, Carrying Capacity, Measures of Concentration and Accessibility, Spatial Interaction, Analysis of Settlement Pattern, Simulation/Gaming:-Frame Games, Empathy Games, Resource Allocation Game, Process Game. Decision Making; Tools and Techniques, Factors- Risk, Turbulence, Uncertainty, Change, Planning Management, Forecasting, Equity, Growth and Development, Analysis of Settlement System.	**08 Hours**
Module -5	
Regional Analysis In Developing Countries: Basic Principles Functional Complexity, Levels of Settlements, Spatial Linkages Analysis, Analytical Mapping Accessibility Analysis, Functional Gap Analysis, Formulation of Spatial Development Strategies, Identification of Investment, Projects, Projects and Program, Monitoring an Evaluation. Institutionalizing Spatial Analysis in the Regional Planning Process, Role of Towns and Cities in the Development of Rural Regions: Physical Input, Economic, Organization and Knowledge Factors, Problems of Rural Regions, Benefits of Physical Linkages, Development of Employment Structure by Sectors: Primary, Secondary and Tertiary.	**08 Hours**

Course outcomes:

- Understand the spatial planning process-its types, functions and dimensions
- Illustrate the methodology used in spatial planning
- Understand the regional planning and analysis especially for developing countries

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Reference books:

1. Kenny Lynch, Rural-Urban Interaction in the Developing World, Taylor & Francis, 2004.
2. Gopal B, Development OfIndias Urban Rural And Regional Planning W. Neha Publishers & Distributors, 2000
3. Harmit Singh Bedi, Smart Urban and Rural Planning Techniques, COPAL Publication, 2015.
4. Kang-Tsung Chang, 'Introduction to Geographic Information Systems', McGraw-Hill Book Company.

Water Treatment Technology & Management

[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLM153	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 03

Course objectives:

- The course is designed to train students in the practical aspects of operating and maintaining water treatment plants, emphasizing safe practices and procedures.

Modules	Teaching Hours
Module -1	**8 Hours**
Introduction: Sources of water, necessity of treatment, Critical Water quality parameters, water quality guidelines and standards for various water uses. **Unit operations:** Principles and design of aeration systems – two film theory, water in air system, air in water system. **Intake structures:** Definition, necessity, advantages**,** Different types.	
Module -2	
Principles of sedimentation: Types of settling and settling equations, design criteria and design of settling tanks. **Principle of Coagulation and Flocculation:** Types of coagulants, coagulant aids, coagulation theory, optimum dose of coagulant, design criteria.	**8 Hours**
Module -3	
Filtration: Theory, types, design criteria and design of filters, filter backwash, operational problems and trouble shooting.	**8 Hours**
Module -4	
Adsorption Process: Types, factors affecting adsorption, kinetics and equilibrium – different isotherm equations and their applications.	**8 Hours**
Module -5	
Unit processes: Disinfection – different types, disinfectants, factors affecting disinfection, methods of disinfection, chemistry of chlorination. Water Softening – Ions causing hardness, Langelier index, various methods. Fluoridation and defluoridation – Principles. Trace organic contaminants in water supplies and their removal. Bench Scale and Pilot Plant studies in water treatment. Rural Water Supply Systems	**8 Hours**

Course outcomes:

On completion of this course, students are able to

- Understand the principles and operation of water treatment systems
- Appraise the suitability of the design of treatment plants and unit processes
- Evaluate process operations and performance
- Understand coagulation, flocculation, and sedimentation, filtration, and disinfection processes.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Reference Books:

1. APHA, AWWA, AAWF, "Water Quality and Treatment "McGraw Hill.
2. Peavy, H.S., Rowe and Tchobonoglous,G., "Environmental Engineering ", McGraw Hill
3. Fair, G.M., Geyer J.C and Okun, Water and Waste water Engineering" Vol II, John Wiley Publications.
4. Weber W.J., "Physico - Chemical Processes for Water Quality Control".
5. CPHEEO Manual on "Water Supply and Treatment", .available at Jain Book agency, C-9, Connaught place, New Delhi
6. Raju, B.S.N., "Water Supply and Wastewater Engineering", Tata McGraw Hill Pvt Ltd., New Delhi.
7. World Health Organization, Geneva, Guidelines for Drinking Water Quality, Third Edition, Volumes 1-3

ADVANCED REMOTE SENSING

[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLM154	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 03

Course objectives:

- To gain the knowledge of optical and microwave remote sensing
- To become familiar with the basic principles and advantages of thermal and Microwave Remote Sensing.

Modules	Teaching Hours
Module -1	
Basic Principles of Remote Sensing : Electromagnetic spectrum: Characteristics of electro-magnetic radiation; Interactions between matter and electro-magnetic radiation; Wavelength regions of electro-magnetic radiation; Types of remote sensing with respect to wavelength regions; active and passive remote sensing, Definition of radiometry; Black body radiation; Reflectance; spectral reflectance of land covers; Spectral characteristics of solar radiation; Radiative transfer equation; energy interaction in the atmosphere; energy interactions with the earth's surface- spectral reflectance curves.	**08 Hours**
Module -2	
Sensors: Types of sensors- passive sensors and active sensors; imaging systems, photographic sensors, characteristics of optical sensors; Sensor resolution- spectral, spatial, radiometric and temporal; Dispersing element; Spectroscopic filter; Spectrometer; Characteristic of optical detectors; Cameras for remote sensing; Film	**08 Hours**

for remote sensing; non-imaging radiometers, imaging sensors, photograph v/s image, Panchromatic, Multispectral, hyperspectral, stereo images, Optical mechanical line scanner; Pushbroom scanner; Imaging spectrometer; spaceborne imaging sensors, active and passive microwave sensors; Thermal sensors; Atmospheric sensors; Sonar; Laser, radar, hyperspectral sensors. Products from scanner data, Image data characteristics, data selection criteria.	
Module -3	
Platforms: Types of platforms- airborne remote sensing, space borne remote sensing; Atmospheric condition and altitude; Attitude of platform; Attitude sensors; Orbital elements of satellite; Orbit of satellite; Satellite positioning systems; satellites for Land, Ocean, and atmospheric studies. **Image Interpretation and Analysis:** Fundamentals of satellite image interpretation; Types of imaging, elements of interpretation; Techniques of visual interpretation; Generations of Thematic maps.	**08 Hours**
Module -4	
Digital Image Processing: Digital data manipulation and analysis; image rectification – Radiometric correction, Atmospheric correction, Geometric correction; image enhancement – Spatial feature manipulation and multi-image manipulation; classification techniques – Supervised classification and unsupervised classification. **Advanced Remote Sensing Technologies**: Synthetic Aperture Radar; Side Looking Airborne Radar; Hyper spectral Imaging Spectrometer; Lidar; Thermal Imaging System; Advanced Laser Terrain Mapping.	**08 Hours**
Course outcomes: Upon completion of this subject students should • have the knowledge of optical and microwave remote sensing for practical applications • Be able to apply the principles of thermal and Microwave RS to the real time problems.	
Question paper pattern: • The question paper will have ten questions. • Each full question consists of 16 marks. • There will be 2full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.	
References Books: 1. George Joseph, "Fundamentals of Remote Sensing", Universities Press, 2005 2. Lillesand & Keifer, "Remote Sensing and Image Interpretation", John Wiley & Sons; ISBN-13: 978-0470052457 3. P. J. Curran, "Physical aspects of Remote Sensing", Longman Group Limited, London. 4. F. F. Sabins, "Remote Sensing Principles and Interpretation", Waveland Press. 5. John R Jensen "Introductory Digital Image Processing: A Remote Sensing Perspective", Pearson Series Geographic Information Science, ISBN- 13: 978-0134058160 6. Robert A. Schowengerdt "Remote sensing Models and methods for image processing",Second edition, 1997, Academic Press.	

ENVIRONMENTAL ENGINEERING LABORATORY

[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLML16	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 02

Course objectives:

- To conduct laboratory studies on water and soil parameters.
- To investigate various physical, chemical and biological parameters of water
- To investigate various physical, chemical and biological parameters of soil

Modules	**Teaching Hours**
Experiment No.1:Estimation of Solids, Acidity, Alkalinity, Hardness, Chlorides and Fluorides Experiment No.2: Determination of pH and Conductivity Experiment No.3:Estimation of Nitrogen(Different Forms like Ammonia, Nitrite) Experiment No4: Estimation of Phosphates and Sulphates Experiment No.5: Estimation of Residual Chlorine Experiment No.6: Determination of Available Chlorine in bleaching powder Experiment No.7: Determination of Dissolved Oxygen Experiment No.8: Atomic Absorption Spectrophotometric Determination of Heavy Metals Experiment No.09: Determination of Biochemical Oxygen Demand Experiment No.10: Estimation of Chemical Oxygen Demand Experiment No.11: Estimation of N, P,K, EC values in soil Experiment No.12: Estimation of Micronutrients in soil (Zinc, Copper, Manganese, Iron, Magnesium)	**40 Hours**

Course outcomes: On completion of this laboratory studies students are able to:

- Investigate independently the various physical, chemical and biological parameters of water and soil.

Reference Books:

1. Sawyer, C. N., McCarty, P. L., and Perkin, G.F., Chemistry for Environmental Engineering and Science, 5th edition McGraw-Hill Inc., 2002
2. B. Kotaiah and Dr. N. Kumara Swamy, Environmental Engineering Laboratory Manual, Charotar Publishing House Pvt. Ltd., 1st Ed., 2007.
3. Standard methods for the examination of water and wastewater, 21st Edition, Washington: APHA., 2012

Conduction of Practical Examination:

1. All laboratory experiments must be included for practical examination.

2. Students are allowed to pick one experiment from **each part and execute both**.

3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks

4. PART –A: Procedure + Conduction + Viva: **10 + 20 +10 (40)**

5. PART –B: Procedure + Conduction + Viva: **10 + 20 +10 (40)**

6. Change of experiment is allowed only once and Marks allotted to the procedure Part to be made zero.

SEMINAR
[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2016 -2017)

Subject Code	16WLM17	IA Marks	100
Number of Practical/ Field Work/ Assignments	03	Exam Marks	-
Total Number of Lecture Hours	40	Exam Hours	-

CREDITS – 01

Seminar Objectives: The objective of this technical seminar is

- to enable the students to read technical article
- to know recent technology developments
- to have research flavor
- to gain knowledge and to share with others

Descriptions

The students should read a recent technical article (try to narrow down the topic as much as possible) from any of the leading reputed and refereed journals like:

1. ASCE Transactions, journals, magazines etc.
2. Springer
3. Elsevier Publications

In the area of (to name few and not limited to):

- Hydrology
- Water Resources and Management
- Water Quality
- Environmental Management
- Groundwater Hydrology and Management etc

Seminar outcomes

After completion of course student will gain:

- Knowledge on new topics.
- Knowledge on technical papers, presentations, writing papers etc
- Knowledge on new trends in various technologies.
- Knowledge gained can be used in internship and main project.
- Knowledge gained about ASCE standards of writing technical papers.

The students has to present at least TWO seminars on the selected topic (try to narrow down the topic as much as possible) and submit a technical report for internal evaluation. The report should result in at least a review/survey article in one of the student's conference.

Note: While writing articles it is responsible of the student and guide/staff-in-charge to take care of plagiarism.

Marks Distribution: Literature Survey + Presentation (PPT) + Report + Question & Answer +Paper: 20 + 30 + 30 + 10 + 10; (=100).

WATERSHED MANAGEMENT

[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLM21	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives:

- To Identify causes of soil erosion
- To Plan and design soil conservation measures in a watershed
- To Plan and design water harvesting and groundwater recharge structures
- To Plan measures for reclamation of saline soils

Modules	Teaching Hours
Module -1 Watershed concepts: Watershed-Topographic divide, Ground water divide, Stream patterns, Soil erosion- Problems, Types, Conservation technology, Peoples involvement, Watershed approach, Watershed Management, Factors influencing watershed operations, Small and Large watersheds, Watershed characteristics, Deterioration of watershed, Watershed delineation, Prioritizing watersheds, Coding of watershed, Morphometric analysis of watershed-Linear, areal and Relief aspects, Channel networks, Hypsometric analysis.	**10 Hours**
Module -2	
Sediment transport: Sediment-Sources, Mechanics of sediment transport, factors affecting sediment yield, Incipient motion, Types of sediment load, Estimation of bed load and suspended sediment load. Estimation of bed load using sampler. Selection of sediment sampling point, Frequency of sampling, Collection of sediment samples, Soil loss estimation by USLE, Modified USLE, Revised USLE and other methods. Soil and water: Soil composition, Soil profile and texture, Significance of soil texture for soil conservation, Infiltration process and rate, Soil moisture condition, Ground water availability, Soil conditions for plant growth, Essential food elements required for plant growth.	**10 Hours**
Module -3	
Land use capability classification: Soil survey, Mapping unit, Purpose of land capability classification, Soil and land use capability-classification, Capability, Limitation; Capability unit; Land capability sub classes, Identification of classes in the field, Land use capability classification, Recommended land use and conservation practices for all capability classes. Erosion control measures in agriculture land: Importance, Contour bunding, Surplussing structures, Graded bunding, Bench Terracing, Land leveling and grading, grassed waterways.	**10 Hours**
Module -4	
Water conservation and harvesting: Introduction, Water conservation methods for crop land, Treatment of catchments, small storage structures- Water harvesting/silt retention structures, Gully control structures, small earth dams, spillways, small weirs, sand dams, drought farm pond, Nala-bunding, Off-stream storage, Developing ground water- Recharge and Extraction, Water harvesting for trees and shrubs. Agronomical measures in soil and water conservation: Land use and conservation agronomy, Grassland Management, Agro-forestry, Horticulture. Erosion control measures in Non-agricultural lands: General- Soil conservation on waste lands, Contour and Staggered trenching, Gully control structures, -sediment retention	**10 Hours**

structure, Retaining walls, Gully and ravine reclamation.	
Module -5	
Watershed Management Practices: Introduction to watershed characteristics, Objectives, People's participation- Importance, Incentives and why to pay incentives, Mobilization of participation, People's organization, Conservation farming, Watershed management plan- General identification of watershed problems, Objectives and Priorities, Socio-economic survey, Watershed map and Preparation of format for watershed management plan.	**10 Hours**

Course outcomes: At the end of the program the student will be able to:

- Identify causes of soil erosion
- Plan and design soil conservation measures in a watershed
- Plan and design water harvesting and groundwater recharge structures
- Plan measures for reclamation of saline soils

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Reference Books:

1. Tideman, E. M., "Watershed Management", Omega Scientific Publishers, New Delhi,2002
2. J. V. S Murthy, Watershed Management, New Age International Publishers, 1998.
3. Suresh Rao, Soil and Water Conservation Practices, Standard Publishers, 2003.
4. V.V. N. Murthy, Land and Water Management, Kalyani Publishers, 1994.
5. Heathcote, I. W., "Integrated Watershed Management" Springer.
6. Strahler, A. H.,"Modern physical geography", John Wiley & Sons, 1991.

SOLID WASTE ENGINEERING AND MANAGEMENT

[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLM22	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives:

- To provide detailed knowledge and skills in solid waste management.
- To provide detailed knowledge of treatment, disposal and recycling options for solid wastes.
- To provide detailed knowledge of principles of existing and emerging technologies for the treatment of waste and recovery of value from waste.

Modules	**Teaching Hours**
Module -1 **Solid Waste**- Types, Sources and Engineering Classification, Characterization, Generation, On-Site Handling, Storage and Processing, Quantification. **Collection of Solid Waste**- Collection Systems,Collection Equipment, Collection Route Optimization.	**10 Hours**

Module -2	
Transfer and Transport- Transfer Stations, Location of Transfer Stations, Transfer Means and Methods. **Processing Techniques**- Mechanical Volume Reduction, Thermal Volume Reduction, Manual Component Separation.	**10 Hours**
Module -3	
Engineering Systems for Resource and Energy Recovery - Materials-Recovery Systems, Recovery Of Biological Conversion Products, Recovery Of Thermal Conversion Products, Recovery of Energy From Conversion Products; Materials And Energy Recovery Systems, Design Examples.	**10 Hours**
Module -4	
Treatment Methods- Recycle And Reuse, Composting, Incineration, Pyrolysis, Design Examples. **Disposal Methods**- Impacts Of Open Dumping, Site Selection, Sanitary Land Filling-Design Criteria and Design Example, Leachate And Gas Collection Systems, Leachate Treatment, Deep-Well Injection.	**10 Hours**
Module -5	
Recent Developments in Solid Waste Reuse and Disposal-Power Generation, Building with Construction Materials And Best Management Practices (BMP). Role of Various Organizations in Solid Waste Management- Governmental, Non-Governmental, Citizen Forums.	**10 Hours**

Course outcomes: On completion of this course, students are able to

- Understand and apply the basic scientific and sustainability principles behind waste management, for solving practical waste management challenges
- Understand the fundamental principles of existing and emerging technologies for the treatment of waste and recovery of value from waste

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Reference Books:

1. Tchobanoglous G., Theissen H., and Eliassen R., “Solid Waste Engineering Principles and Management Issues”, McGraw Hill, New York.
2. Peavey, Rowe and Tchobanoglous, “Environmental Engineering”, McGraw Hill.
3. Mantel C. L.,(1975), “Solid Waste Management”, John Wiley
4. Pavoni J.L., “Handbook of Solid Waste Disposal”.

ADVANCED IRRIGATION ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLM23	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives:

- To know about history and development of irrigation in India
- To understand soil water movement in the root zone of agricultural crops
- To understand crop water requirement of different crops to fix the duration and frequency for irrigation.
- To Know about economics of irrigation projects

Modules	Teaching Hours
Module -1 **General:** Irrigation Development in India: Historical review modern trances-inter disciplinary approach. **Agricultural Hydrology:** Subsurface water, storage zones, Soil physics-mechanics of flow, Soil water, measurement, metric potential, models of soil water movement. Infiltration and groundwater recharge. Return flow analysis	**10 Hours**
Module -2	
Soil and Land Management in Agriculture: Soil Management in relation to water use-soil horizons, classification and surveys-land capability farm development: size of farm unit, land development in relation to solid characteristics and irrigation practices-conservation village-land shopping and grading-equipment.	**10 Hours**
Module -3	
Crop requirements and irrigation scheduling : Major Indian crops times of sowing and harvesting –critical periods of growth moisture stress, nutritional disorders-rooting depths-consumptive use of crop blanney-criddle, Thornthwait penman, Christiansen methods-crop selection crop water requirements, duty period depth and frequency of application protective irrigation –irrigation schedules in relation to crop requirements and maximum water-use efficiency scope of computerization-cropping patterns-soil water, fertilizer and plant interactions.	**10 Hours**
Module -4	
Water conveyance and application lined and unlined channels-seepage losses-water control and diversion structure structures in field channels and drain: their design and location- underground pipe system application methods: border, check, basin, furrow and sprinkler irrigation, sub irrigation and drip irrigation –relative merits.Glances of water logging-design of surface and subsurface drains-saline and alkaline lands reclamation and management of Salt affected lands	**10 Hours**
Module -5	
Economics of Irrigation: Objectives of resources development. Costs and benefits, Efficiency-objective-economic growth, income redistribution-net benefit-function and optimality conditions. Optimization techniques and command area planning-system technique, linear and dynamic programming methods.	**10 Hours**

Course outcomes: At the end of the course the student will be able to:

- Explain history and development of irrigation in India
- Understand soil water movement in the root zone of agricultural crops
- Fix the duration and frequency for irrigation based on crop water requirement of different crops
- Do economic analysis of different alternative projects available for irrigation

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Reference Books:

1. Modi. P. N., Irrigation, Water Resources & Water Power Engineering- Standard Publishers, New Delhi
2. Linsley, R. K. and Frazinini, J. B.,-"Water Resources Engineering"2nd Ed. McGraw Hill, NY
3. Chaturvedi. M.C, "Water Resources Systems Planning and Management" Tata McGraw Hill. NY
4. James L.D and Lee R.R"Economics of Water Resources Systems Planning" McGraw Hill. NY
5. B. C. Punmia, Pande, Ashok kumar and Arunkumar Jain "Irrigation and water power engineering" Laxmi Publications (P) LTD.
6. Santhosh Kumar Garag "Irrigation Engineering" Khanna Publishers, Delhi
7. Mays, Handbook of Resources

GROUND WATER HYDROLOGY

[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLM24	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03
CREDITS – 04			

Course objectives:

- To Introduce groundwater hydrology
- To understand Groundwater Flow in Aquifers
- To Model Groundwater Flow in Aquifers
- To know Geophysical Methods in Groundwater Exploration

Modules	Teaching Hours
Module -1	
General Water Balance, Regional Ground Water Balance, Distribution of Subsurface Water, Different Types of Aquifers, Heterogeneity and Anisotropy, Occurrence of Ground Water in Hydro Geological Formations, Structure and Types of Wells. – Problems on estimation of basic parameters.	**10 Hours**
Module -2	
Governing Equation of Groundwater Flow in Aquifers. Derivation of General Differential Equations for Ground Water Flow, Regional Ground Water Problems, Governing Equations for Transient Flow Conditions.	**10 Hours**

Module -3	
Models for Ground Water Analysis: Introduction, Major Applications of Groundwater Models, Numerical Modelling of Groundwater Systems, Groundwater Modelling by the Finite Difference (FD). –Problems. Pollution of Groundwater: Hydrodynamic Dispersion of Pollutants in Groundwater Environment (Advection dispersion, Molecular diffusion) Optimization models for management of groundwater quantity and quality.	**10 Hours**
Module -4	
Well Hydraulics: Analysis of Steady Radial Flow Towards a Well in a confined Aquifer, Dupuit Forcheimmer (DF) Theory of free Surface Flow For Steady Flow in Unconfined Aquifers, Analysis of Steady Radial Flow in Laterlly Stratified Phreatic Aquifers. Problems on well Hydraulics.	**10 Hours**
Module -5	
Artificial Recharge: Spreading methods, Induced-recharge method, Recharge-well method, Subsurface dams, Wastewater discharge, Recharge by urban storm runoff, Case history. Geophysical Methods in Groundwater Exploration, Introduction, Electrical Resistivity Method, Analytical Derivation for Resistivity in Vertical Electrical Sounding, Seismic Retraction Method, Determination of Aquifer Thickness, Geologic and Hydrologic methods, Hydrogeologic well logging, Tracer techniques.	**10 Hours**

Course outcomes: On completion of this course, students are able to

- Apply the governing equation of groundwater flow for different cases
- Carryout physical investigation for groundwater resource
- Apply various techniques for assessment, development and management of groundwater.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Reference Books:

1. A. K. Rastogi., Numerical Groundwater Hydrology, Penram International Publishing (India) Pvt.Ltd.2007.
2. Todd D.K. & Mays, L.W., “Ground Water Hydrology”, 3 Ed, Wiley.
3. Raghunath H.M., “Ground Water”, New Age Publishers, 2007.

URBAN FLOOD MANAGEMENT

[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLM251	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 03

Course objectives:

- To explain the urban flooding-its types and characteristics, influence of urban density on floods
- To understand the key uncertainties of climate and expected consequences of climate change
- To explain the types of flood damages, loss of life estimation and to explain impacts of land use change on runoff
- To elaborate the concept of Resilience, Vulnerability, Robustness & Sustainability of flood response
- To analyze and design the SUDS systems and FFWRS
- To acquire deeper knowledge of disaster mitigation and management

Modules	Teaching Hours
Module -1 **Introduction:** The influence of climate, causes of flooding, types of flooding, fluvial/pluvial flooding, principles of landuse planning **Climate Change: Key uncertainties and Robust Findings:** A review of the past, signs of change, Expected consequences.	**08 Hours**
Module -2	
Hydrology of cities: Urban hydrological cycle, Land use & runoff, Urban flood risk assessment, Tangible & intangible damages, Loss of life estimation in flood risk assessment, flood risk mapping	**08 Hours**
Module -3	
Responding to Flood Risk: Responses, Performance, Standards & Expectations, Resilience, Vulnerability, Robustness & Sustainability, Precautionary & Adaptive responses, Confronting flood management with land use planning, Building types, infrastructure & public open spaces	**08 Hours**
Module -4	
Urban drainage systems: A historical perspective, Major & Minor flows, SUDS/LIDS, Practices in water sensitive urban design **Enhancing coping & recover capacity:** Flood forecasting warning and response, Emergency Planning, Management & Evacuation	**08 Hours**
Module -5	
Disaster mitigation & Management: Modes of disaster management, primary & secondary data, EIA of flood management structures, traffic management during floods, socio-economic studies, interdepartmental cooperation, Regional & global disaster mitigation measurement.	**08 Hours**

Course outcomes: At the end of the course student will be able to:

- Understand the urban flooding-its types and characteristics, influence of urban density and climate change on urban floods
- Explain the types of flood damages, loss of life estimation and to explain impacts of

land use change on runoff

- Analyze and design the SUDS systems and FFWRS

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Reference Books:

1. Chris Zevenbergen, Adraian Cashman, Erik Pasche and Richard Ashely. "Urban Flood Management", CRC Press-2010 Edition.
2. Wheater, H. S., Mcintyre, N., Jackson, B. M., Marshall, M. R., Ballard, C., Bulygina, N. S., Reynolds, B. and Frogbrook, Z. "Multiscale Impacts of Land Management on Flooding", Wiley-Blackwell, Oxford, UK, (2010).
3. Richard Ashley, Stephen Garvin, Erik Pasche, Andreas Vassilopoulos, Chris Zevenbergen. "Advances in Urban Flood Management" CRC Press-2007 Edition.
4. Arun Kumar. "Handbook of Flood Management: Flood Risk Simulation, Warning, Assessment and Mitigation", SBS Publisher, India, Vol. 1 2009.

Wastewater Engineering & Management

[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLM252	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 03

Course objectives:

- To provide a basic description and understanding of the principal unit processes used in the treatment of wastewater.
- To understand the scientific basis of each unit process, as well as the conventional approach to their engineering design.
- To provide an understanding of the kinetic theory of biological growth and apply it to typical aerobic processes, and an appreciation of the purpose and practice of sludge treatment..

Modules	Teaching Hours
Module -1 **Objectives of wastewater treatment:** Characteristics, flow variations, types of reactors. Wastewater Treatment Flow Diagrams and Hydraulic Profile. **Kinetics of biological treatment systems: B**iokinetic constants and their determination, batch and continuous systems.	**08 Hours**
Module -2	
Theoretical principles and design: Screens, equalization basin, grit chamber, primary and secondary settling tanks.	**08 Hours**
Module -3	
Theoretical principles and design: Suspended growth system - conventional activated	**08 Hours**

sludge process and its modifications. Attached growth system – trickling filter, bio-towers and rotating biological contactors. Principles of stabilization ponds.	
Module -4	
Advanced Wastewater Treatment: Need and technologies used. Nitrification and Denitrification Processes, Phosphorous removal. Wastewater disinfection.	**08 Hours**
Module -5	
Sludge Processing: Separation - sludge thickeners, volume reduction, conditioning and digestion – aerobic and anaerobic. **Rural wastewater systems: S**eptic tanks, two-pit latrines, eco-toilet, soak pits.	**08 Hours**

Course outcomes: At the end of the course the student will be able to:

- A process flow sheet.
- Appropriate treatment methods for municipal and certain industrial effluents.
- How water and wastewater treatment plants operate.
- Simple design equations for water and wastewater treatment plant.
- The chemical and biological prociples behind unit processes used in water and wastewater treatment unit processes.
- The concept of a unit operation and a unit process.
- The fundamental scientific processes underlying the design and operation of wastewater treatment plant.
- The management of residuals from water and wastewater treatment.
- The methods that are used for the design of a water and wastewater treatment plant.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Reference Books:

1. Metcalf and Eddy Inc., "Wastewater Engineering - Treatment and Reuse", 4th Edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
2. Gaudy, "Advanced Wastewater Treatment"
3. Benefield R.D., and Randal C.W., "Biological Process Design for Wastewater Treatment", Prentice Hall, Englewood Chiffs, New Jersey.
4. Karia G.L., and Christian R.A., "Wastewater Treatment Concepts and Design Approach" , Prentice Hall of India Pvt. Ltd., New Delhi.
5. Ronand L., and Droste, "Theory and Practice of Water and Wastewater Treatment", John Wiley and Sons Inc.
6. Fair G.M., Geyer J.G and Okun, "Water-wastewater Engineering".
7. Lee C.C., and Lin S.D., "Handbook of Environmental Engineering Calculations", McGraw Hill, New York.
8. "Industrial Safety and Pollution Control Handbook", National Safety Council and Associate (Data) Publishers Pvt. Ltd.

GROUND IMPROVEMENT TECHNIQUE

[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLM253	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 03

Course objectives:

- To Know Principles and objectives of ground improvement
- To Study dewatering systems, filtration, drainage and seepage control with geosynthetics, preloading and vertical drains.
- To apply treatment for problematic soils- collapsible and expansive soils
- To study principles, concepts and mechanism of reinforced earth.

Modules	Teaching Hours
Module -1 Principles and objectives of ground improvement. **Mechanical modifications**: principles and methods of densification, properties of compacted soils, compaction control tests, deep and shallow compactions of coarse and fine grained soils – vibro- floatation, compaction piles, dynamic compaction, specification for compaction	**08 Hours**
Module -2	
Hydraulic modifications: dewatering systems, filtration, drainage and seepage control with geosynthetics, preloading and vertical drains, electro- kinetic dewatering.	**08 Hours**
Module -3	
Admixtures of subgrades of pavements; stabilization using industrial wastes; grouting-modification by intrusion and confinement. **Stabilization**: role of admixtures, methods of chemical stabilization- lime, cement, bitumen and special chemicals; mechanisms, uses and limitations.	**08 Hours**
Module -4	
Improvement of soft grounds and low lands: treatment for problematic soils-collapsible and expansive soils, nature of problems and remedial/preventive measures. **Reinforced earth technique:** principles, concepts and mechanism of reinforced earth. Materials, design consideration for reinforced earth structures-retaining walls, embankments, bearing capacity problems and pavements. Reinforced earth construction for control of heaves. Soil nailing , design examples.	**08 Hours**
Module -5	
Geosynthetic materials: functions, property characterization, testing methods for geosynthetic materials, geotextiles, geomemberanes, geogrids, geonets and geocells.	**08 Hours**

Course outcomes: At the end of the course the student will be able to:

- Define Principles and objectives of ground improvement
- Apply dewatering systems, filtration, drainage and seepage control with geosynthetics, preloading and vertical drains.
- Apply treatment for problematic soils- collapsible and expansive soils.
- Define principles, concepts and mechanism of reinforced earth.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Reference Books:

1. Purushotham Raj, Ground Improvement Techniques, Laxmi publications, New Delhi.
1. Swami saran, reinforced soil and its engineering applications textbook JK Internationapvt ltd., 2010
2. G.L. Shivakumra Babu, An Introduction to Soil Reinforcement and Geosynthetics, Orient Longman, India.
3. Koener R.M., "Construction and Geotechnical Methods in Foundation Engineering", McGraw Hill Pub. Co., New York, 1985.
4. Hausmann, M. R., "Engineering principles of ground modification", McGraw –Hill Pub.Co.Newyork,1990.
5. Ingles O.G. and Metcalf J.B., "Soil Stabilization processes and practice", Butterworths, London, 1972.
6. Bell F.G., "Methods of treatment of unstable ground", Newness Butterworth, London,1975.
7. Nelson J.D., and Miller D.J., "Expansive soils", John Wiley and sons. Inc. NewYork,1992.
8. Koerner R.M., "Designing with Geosynthetics", Prentice Hall Pub.1994.
9. Jones C.J.E.P., "Earth Reinforcement and Soil Structures", Butterworth, London,1996.
10. Koerner R.M., and Welsh J. P., "Construction and Geotechnical Engineering using Synthetic Fabrics", Wiley Interscience, New York, 1980.
11. Bell F.G., "Ground Engineer's Reference Book", Butterworths, London, 1987.
12. Winterkorn H.F. and Fong H.Y., "Foundation Engineering Hand Book", Galgotia Book Source, NewDelhi, 2000.

WATER QUALITY MODELLING AND MANAGEMENT

[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLM254	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03
CREDITS – 03			

Course objectives:

- To know the process of pollution contaminant mechanism
- To know the water quality modeling Techniques
- To know water quality management measures

Modules	Teaching Hours
Module -1 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 and dispersion.	**08 Hours**

Module -2	
River and streams, convective diffusion equation and its applications, estuaries, estuarine hydraulics, estuarine water quality models. Lakes and reservoirs.	**08 Hours**
Module -3	
Contaminant transport in unsaturated variable soils, contaminant transports in ground water advection, dispersion, one dimensional transport with linear absorption	**08 Hours**
Module -4	
Dual porosity models, numerical models, bio-degradation reaction. Water quality management, socio-economic aspects of water quality management.	**08 Hours**
Module -5	
Management alternatives for water quality control, waste load allocation process. Lake quality management, ground water remediation.	**08 Hours**

Course outcomes:

At the end of the course student will able to

- Identify the transport of contamination
- Model the water quality transport
- Take the preventive measures for water quality contamination.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Reference Books:

1. Robert V. Thomann and John A. Mueller, Principles of surface water quality modelling and control. Harper & Row, 1987, ISBN 060466774, 9780060466770
2. Steven C. Chapra, "Surface water quality modelling". McGraw-Hill, 1997. ISBN: 0071152423, 9780071152426
3. Jerald L. Schnoor, "Environmental Modelling". Publisher: John Wiley and Sons Ltd, 1996, ISBN:9780471124368
4. Thomann, "Systems Analysis and Water Quality Management". McGraw-Hill Inc.,US, ISBN-13: 978-0070642140
5. A. K. Rastogi, "Numerical Groundwater Hydrology", International Publishing (India) Pvt. Ltd. (2007).

COMPUTATIONAL LABORATORY

[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLML26	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 02

Course objectives:

- To be able prepare and analysis of spatial data.
- To be able use hydrological simulation models.

Modules	Teaching Hours
GIS Application 1. Map registration/ Geo-referencing 2. Digitization 3. Map projection 4. Basics of Geo-database 5. Image Classification	**20 Hours**
Simulation Models: 1. EPA NET 2. CROPWAT 3. HEC RAS	**20 Hours**

Course outcomes: On completion of this laboratory studies students are able

- To Prepare and analysis the spatial data for management of water and land resources.
- To use simulation model to generate information on hydrological responses of the study area.

Conduction of Practical Examination:

1. All laboratory experiments must be included for practical examination.
2. Students are allowed to pick one experiment from each part and execute both.
3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks
4. **PART –A: Procedure + Conduction + Viva: 10 + 20 +10 (40)**
5. **PART –B: Procedure + Conduction + Viva: 10 + 20 +10 (40)**
6. **Change of experiment is allowed only once and Marks allotted to the procedure Part to be made zero.**

SEMINAR

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2016 -2017)

Subject Code	16WLM27	IA Marks	100
Number of Lecture Hours/Week	03	Exam Marks	-
Total Number of Lecture Hours	40	Exam Hours	-

CREDITS – 01

Seminar Objectives: The objective of this technical seminar is

- to enable the students to read technical article
- to know recent technology developments
- to have research flavor
- to gain knowledge and to share with others

Descriptions

The students should read a recent technical article (try to narrow down the topic as much as possible) from any of the leading reputed and refereed journals like:

1. ASCE Transactions, journals, magazines etc.
2. Springer
3. Elsevier Publications

In the area of (to name few and not limited to):

- Hydrology
- Water Resources and Management
- Water Quality
- Environmental Management
- Groundwater Hydrology and Management etc

Note: Preferably topic should be interconnected with first semester seminar topic or different case studies should be included which my help directly or indirectly for final dissertation work.

Seminar outcomes

After completion of course student will gain:

- Knowledge on new topics.
- Knowledge on technical papers, presentations, writing papers etc
- Knowledge on new trends in various technologies.
- Knowledge gained can be used in internship and main project.
- Knowledge gained about ASCE standards of writing technical papers.

The students has to present at least TWO seminars on the selected topic (try to narrow down the topic as much as possible) and submit a technical report for internal evaluation. The report should result in at least a review/survey article in one of the student's conference.

Note: While writing articles it is responsible of the student and guide/staff-in-charge to take care of plagiarism.

Marks Distribution: Literature Survey + Presentation (PPT) + Report + Question & Answer +Paper: 20 + 30 + 30 + 10 + 10; (=100).

III Semester: INTERNSHIP

Sl No.	Subject Code	Title	Teaching Hours/Week		Examination			Total Marks	Credits
			Lecture	Practical / Field Work/ Assignment	Duration (Hours)	I.A Marks	Theory/Practical Marks		
1	16WLM31	Seminar/ Presentation on Internship (After 8 weeks from the date of commencement)	-	-	-	25	-	25	20
2	16WLM32	Report on Internship	-	-	-	25	-	25	
3	16WLM33	Evaluation and Viva-Voce of Internship	-	-	-	-	50	50	
4	16WLM34	Evaluation of Project Phase-1	-	-	-	50	-	50	1
Total			-	-	-	**100**	**50**	**150**	**21**

ENVIRONMENTAL IMPACT ASSESSMENT

[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLM41	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives:

- To know about objectives and scope of EIA
- To understand various Methodologies/Techniques of EIA-checklist
- To Assess and Predict Impacts of ecological attributes
- To study various mitigation measures

Modules	Teaching Hours
Module -1 **Introduction to EIA:**Introduction to EIA, Development Activity and Ecological Factor, Need for EIA Studies, Step-by-step procedures for conducting EIA, EIS, FONSI, Limitations of EIA, Environmental Setting, Objectives and Scope, Contents of EIA, Transnational effects of projects, Problems of EIA in developing countries	**10 Hours**
Module -2	
EIA Methodologies:, Methodologies/Techniques of EIA-checklist, matrix, network analysis, environmental index, overlay, simulation method and cost benefit analysis technique.	**10 Hours**
Module -3	
Assessment and Prediction: Assessment and Prediction of Impacts of ecological attributes and mitigation measures - Air, Surface-Water, Noise, Soil and Groundwater, Biological Environment, Cultural and Socio-economic Environment, Rapid and Comprehensive EIA, EIA Regulations in India.	**10 Hours**
Module -4	
Public Participation: Public Participation in Environmental Decision making. Practical Considerations in preparing Environmental Impact Assessment and Statements	**10 Hours**
Module -5	
Case Studies: EIA for Water resource developmental projects, Highway projects, Nuclear-Power plant projects, Mining project (Coal, Iron ore), Thermal power plant project, Pharmaceutical industries, Textile industries.	**10 Hours**

Course outcomes: At the end of the course the student will be able to:

- know about objectives and scope of EIA
- understand various Methodologies/Techniques of EIA-checklist
- Assess and Predict Impacts of ecological attributes
- Implement various mitigation measures

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Reference Books:-

1. L. W. Canter, Environmental Impact Assessment, 2nd Ed., McGraw-Hill, 1996
2. Y. Anjaneyulu, ValliManickam. "Environmental Impact Assessment Methodologies", CRC Press, 2011
3. Jain R.K. Urban L.V. and Stacey G.S. "Environmental Impact Analysis: A New Dimension in Decision Making", 2nd Ed., Van Nostrand Reinhold Co. New York. 1981.
4. R. Therivel, John Glasson, Andrew Chadwick, Introduction to Environmental Impact Assessment (Natural and Built Environment), Routledge, 2005

WETLAND MANAGEMENT

[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLM421	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03
CREDITS – 03			

Course objectives:

- To understand history and definitions of Wetlands
- To know about wetland classification and delineation
- To have knowledge of major wetland indicators i.e. Hydrology, Hydric soil and Hydrophytes
- To understand different techniques of wetland conservation, restoration and creation

Modules	Teaching Hours
Module -1 **Introduction:** History, definition of wetlands, Wetland indicators, Wetland Laws, National wetland inventory, Status and trends of wetlands, The Ramsar Convention.	**08 Hours**
Module -2	
Wetland Classifications: Cowardin's and Hydro geomorphologic wetland classification system. Types and Classification of wetlands (based on Source): Precipitation, surface water and groundwater. Wetland delineation-Technical guidelines, Characteristics and indictors, Methods-preliminary data gathering and synthesis, Selection of methods.	**08 Hours**
Module -3	
Wetland Indicators: Wetland Hydrology-Hydrologic cycle, Criteria and field indicators, Kinds of hydrological data,. Wetland recharge and discharge, wetland water budget and balance. **Wetland Soils**-Characteristics, Indicator guidelines, field indicators of Hydric soils, Test indicators of Hydric soils. **Wetland vegetation/ hydrophytes:** Characteristics, indicator guidelines, influencing factors, classification, Functions and values.	**08 Hours**
Module -4	
Wetland conservation and Development: Wetland ecosystems and its environmental significance, Factors affecting wetland habitats. Wetland management-Definition and classification, Wetland values and functions, Wetland degradation and loss, Conservation of wetlands, Wetland management principles. Identifying major problems and Setting objectives and priorities, Management of wetland habitats for ecological processes and wildlife.	**08 Hours**

Module -5	
Wetland Assessment and Monitoring: Natural and constructed wetlands, Managing wetlands for multifunctional benefits, the role of landscape architects in wetlands. Floating Islands-An Alternative to Urban Wetlands and case studies.	**08 Hours**

Course outcomes: At the end of the course the student will be able to:

- Explain a history of wetlands and define a Wetland
- Delineate wetlands based on different classifications
- Identify major wetland indicators i.e. Hydrology, Hydric soil and Hydrophytes
- Apply different techniques for wetland conservation, restoration and creation

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

References:

1. William J. Mitsch, James G. Gosselink, "Wetlands", Published by John Wiley and sons, Inc., Hoboken, New Jersy, Canada
2. Gail Brooks, Jon A. Kusler, “Wetland Hydrology”, Association state wetland managers.
3. Falconer, R. A and Goodwin, P (Ed), "Wetland Management", 1994, Thomas Telford, London.
3. Bruce E. Hammer., "Constructed Wetlands for Wastewater Treatment", 1989, CRC-Press; I Ed.
4. J.T.A. Verhoeven., "Wetlands and natural resource management".

GROUNDWATER ASSESSMENT, DEVELOPMENT AND MANAGEMENT

[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLM422	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 03

Course objectives:

- To understand groundwater flow
- To Evaluate aquifer properties
- To Understand groundwater development and management technique
- To apply mathematical model for assessment of groundwater

Modules	**Teaching Hours**
Module -1 **Zones of Aeration and Saturation**: Zone of aeration, Zone of saturation, Storage efficient of aquifers, Fluctuations of the water table, Fluctuations of the piezometric surface, Recharge and discharge areas. **Ground Water Flow**: Properties of water in relation to flow, Head distribution, Laminar and turbulent flow, Darcy’s law. Formation constants, Flow through aquifers.	**08 Hours**

Module -2	
Evaluation of Aquifer Properties: Aquifer tests, Confined aquifers, Semiconfined aquifers, Unconfined and semiunconfined aquifers, Transition for artesian to water table conditions, Bounded aquifers, Partially penetrated aquifers, Sloping piezometric and phreatic surfaces, Areal methods. Sea Water Intrusion: Sea Water Intrusion in Coastal Aquifers, Modelling of Pollutant Transport in the Unsaturated Zone. Prevention and Control of Seawater Intrusion.	**08 Hours**
Module -3	
Ground Water Recharge, Discharge and Balance: Parameters of Ground-Water Balance, Estimation of Recharge Components, Nuclear Methods, Estimation of Ground Water Discharge, Ground Water Resources Evaluation In India, Case History.	**08 Hours**
Module -4	
Ground Water Development and Management: Ground-Water Development, Water logging, Conjunctive use, Desalination, Modelling Techniques in Ground-Water Management, Ground Water Legislation. **Management of Groundwater**: Pollution in Relation to water use, Municipal sources and causes, Industrial sources and causes, Agricultural sources and causes, Miscellaneous sources And causes, Attenuation of Pollution, Monitoring Groundwater Quality	**08 Hours**
Module -5	
Groundwater Basin Management and Conjunctive Use: Groundwater Basin Management, Conjunctive Use, Mathematical modelling of a dual aquifer system.	**08 Hours**

Course outcomes:

On completion of this course, students are able to

- Assess the different aquifer properties
- Apply mathematical model for assessing groundwater
- Evaluate and apply groundwater management techniques

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

References Books:

1. K. R. Karanth, Ground Water Assessment Development and Management, Tata McGraw-Hill Publishing Company Limited, New Delhi.1.
2. David Keith Todd, Groundwater Hydrology, Gopsons Paper Ltd., Noida, Second Edition.
3. H. M. Raghunath, Ground Water, New Age International (P) Ltd., New Delhi, Third Edition.

Industrial Waste Management and Audit

[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLM423	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 03

Course objectives:

- To provide an understanding of the mechanisms and processes used to treat waters that have been contaminated in some way by anthropogenic industrial or commercial activities prior to its release into the environment or its re-use.
- To understand various terms used in industrial wastewater treatment and to acquaint with different steps involved in treatment of industrial wastewater.

Modules	Teaching Hours
Module -1 **Effects of Industrial Wastes** on sewerage system and sewage treatment plants and receiving water bodies. Effects of waste additions on physical and chemical properties of soil. **Effluent standards and receiving water quality standards**. Different aspects and choices of various disposal alternatives.	**08 Hours**
Module -2	
Industrial Waste survey-Process flow charts, condition of waste stream. Material balance, Sampling – Grab, Composite and integrated samples. Continuous monitoring – pH, Conductivity, Biomonitoring	**08 Hours**
Module -3	
Pretreatment of Industrial Wastewater – Volume reduction, Strength reduction, Neutralization, Equalization and Proportion, Removal of Organic and inorganic dissolved solids. **Wastewater Treatment in specific industries:** Sugar, Pulp and paper, Cement, Textile, Tannery, Dairy.	**08 Hours**
Module -4	
Design of complete treatment system & disposal for industries: Diary, Textile, paper and pulp mill to meet P.C.B. norms. **Radio Active Wastes treatment**- Low activity and high activity radiation, application of radio active techniques for wastewater treatment. **Bio-Remediation** of contaminated soils	**08 Hours**
Module -5	
Environmental Auditing: Introduction, Cost of Pollution, Importance of Environmental audit and solutions, Financial and Managerial opportunities.	**08 Hours**

Course outcomes: After completion of course student will be able to:

- Learn physical/chemical/biological characteristics of and the evaluation technique for various industrial wastewater.
- Understand the theory, engineering application, and design technique for the industrial wastewater treatment unit processes.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Reference Books

1. Nemerow N.N., "Liquid Waste of industry theories, Practices and Treatment". Addison Willey New York.
2. Azad N. S., "Industrial Wastewater Management Hand Book" McGraw Hill book Co., New York.
3. Ross R.D. "Industrial Waste Disposal", Reinhold Environmental Series – New York.
4. Dickinson" Practical Waste Treatment and Disposal Applied Science publication, London.
5. Mahajan," Pollution control in Process industries". TMH, New Delhi.
6. Eckenfelder, "Industrial Water pollution Control"- McGraw hill Company, New Delhi American Chemical Society, Washington D.C. USA

Global Warming and Climate Change

[As per Choice Based Credit System (CBCS) scheme]

Subject Code	16WLM424	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03
CREDITS – 03			

Course objectives: To provide an understanding of:

- The factors responsible for climate change,
- The biological and sociological consequences of such changes; and
- The possible engineering, economic, and legal solutions to avoid more extreme perturbations.

Modules	Teaching Hours
Module -1	
Introduction: Radiative forcing, Earth Albedo, Irradiance, Energy budget. Scientific principles- warming earth and Principle of thermodynamics	**08 Hours**
Module -2	
Green-House Effect as a Natural Phenomenon, Green House Gases GHGs) and their Emission Sources and sinks of $C0_2$, Methane, Nitrous oxides, carbon cycle disequilibrium, Global Warming Potential (GWP) of GHGs Characterization & Classification of atmospheric pollutants,–description and application of point, line and areal sources.	**08 Hours**
Module -3	
Climate change- Climate change trends. Components of climate change process, Ozone layer depletion and its control, **Impacts of climate change:** Global and India, Temperature Rise, Sea Level rise, Coastal Erosion and landslides, Coastal Flooding, Wetlands and Estuaries loss Impact of ocean current on global climate, EL-NINO & LA-NINA effects	**08 Hours**

Module -4	
Kyoto Protocol: Importance, Significance and its role in Climate Change **Carbon Trading** - Mechanisms, Various Models (Indian) Global and Indian Scenario	**08 Hours**
Module -5	
Cleaner Development Mechanisms: Various Projects related to CO2 Emission Reduction. **Alternatives of Carbon Sequestration:** Conventional and non-conventional techniques , Role of Countries and Citizensin Containing Global Warming	**08 Hours**

Course outcomes:

On completion of this course, students are able to:

- Measure climate factors and how they change
- Understand connections between global warming and human activities
- Identify effects of climate change on biodiversity and ecosystems in different biomes and aquatic systems
- Model possible scenarios for future climate change
- Achieve possible ways to deal with climate change.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Reference Books:

1. Barry R.G., and Chorley R.L., "Atmosphere, Weather and Climate", 4th Edition, ELBS Publication.
2. Bolin B., "Carbon Cycle Modelling", John Wiley and Sons Publications.
3. Corell R.W., and Anderson P.A., "Global Environmental Change", Springler Verlog Publishers.
4. Francis D., "Global Warming: The Science and Climate Change", Oxford University Press.
5. Frame B., Medury Y., and Joshi Y., "Global Climate Change: Science, Impact and Responses".
6. Linden E.,, "The Winds of Change: Climate, Weather and the Destruction of Civilizations", Simon and Schuster Publications.
7. Mintzer I.M.,"Confronting Climate Change, Risks, Implications and Responses", Cambridge University Press.
8. Srivatsava A.K., "Global Warming", APH Publications.
9. Wyman R.L., "Global Climate Change and Life on Earth", Chapman and Hall Publications.
10. Yadav, Chander and Bhan, "Global Warming: India's Response and Strategy", RPH Publications.