DEPARTMENT OF WATER AND LAND MANAGEMENT

VISION

To be a knowledge centre in water and land management education, research and practical field for creating sustainable environment and enhancing quality of life.

MISSION

Develop a specialised professional by imparting quality education and training. Attain international standards in teaching, education, research and consultancy.

PROGRAM EDUCATIONAL OBJECTIVES

The graduating students of the Water and Land Management Program will be able to:

PEO1.	Apply knowledge of basic sciences and engineering to analyze water and Land Management practices for socio-economic development
PEO2.	Identify the sources of water, Capabilities of different soil and their characteristics.
PEO3.	Plan and design water and Land Management strategies.
PEO4.	Analyze complex field situations and provide engineering solutions for land and water management aspects.
PEO5.	Communicate effectively, and lead multidisciplinary teams to solve water related issues with professional ethics.
PEO6.	Provide scientific inputs to decision makers.

PROGRAM OUTCOMES: At the end of the program the student will be able to:

PO1	Analyze hydro meteorological data and components of hydrological cycle
PO2	Assess surface and groundwater resources
PO3	Plan water resources projects for meeting socio-economical and environmental needs
PO4	Design and manage water resources systems for optimal utilization
PO5	Manage land and water in the changing climate scenario
PO6	Analyze hydrologic extremes and adopt suitable management practices to minimize impacts
PO7	Work and lead in multi disciplinary environment and demonstrate professional and social ethics
PO8	Engage in critical thinking and pursue lifelong learning for professional advancement

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examination – 2018-19
M.Tech Water & Land Management (WLM)
Outcome Base Education (OBE) and Choice Based Credit System (CBCS)

I SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
				Theory	Practical/ Field work/ Assignment	Duration in hours	CIE Marks	SEE Marks	Total Marks	
1	PCC	18WLM11	Optimization Techniques	04	--	03	40	60	100	4
2	PCC	18 WLM12	Surface Water Hydrology	04	--	03	40	60	100	4
3	PCC	18WLM13	Design of Hydraulic Structures	04	--	03	40	60	100	4
4	PCC	18WLM14	Remote Sensing & GIS	04	--	03	40	60	100	4
5	PCC	18WLM15	Water Pollution Control	04	--	03	40	60	100	4
6	PCC	18WLML16	Environmental Engg. Lab	-	04	03	40	60	100	2
7	PCC	18RMI17	Research Methodology and IPR	02	--	03	40	60	100	2
			TOTAL	**22**	**04**	**21**	**280**	**420**	**700**	**24**

Note: PCC: Professional core, PEC: Professional Elective.

Internship: All the students shall have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination will be conducted during III semester and prescribed credit shall be counted for the same semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up /complete the internship shall be declared as failed and have to complete during subsequent University examination after satisfy the internship requirements.

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II SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
				Theory	Practical/ Field work/ Assignment	Duration in hours	CIE Marks	SEE Marks	Total Marks	
1	PCC	18 WLM 21	Watershed Management	04	--	03	40	60	100	4
2	PCC	18 WLM 22	Groundwater Hydrology	04	--	03	40	60	100	4
3	PCC	18WLM23	Solid Waste Engineering & Management	04	--	03	40	60	100	4
4	PEC	18WLM24X	Professional elective 1	04	--	03	40	60	100	4
5	PEC	18WLM25X	Professional elective 2	04	--	03	40	60	100	4
6	PCC	18WLML26	Computational-Laboratory	--	04	03	40	60	100	2
7	PCC	18WLM27	Technical Seminar	--	02	--	100	--	100	2
TOTAL				**20**	**06**	**18**	**340**	**360**	**700**	**24**

Note: PCC: Professional core, PEC: Professional Elective

Professional Elective 1		Professional Elective 2	
Course Code under 18WLM24X	**Course title**	**Course Code under 18XXX25X**	**Course title**
18WLM241	Advanced Remote Sensing	18WLM251	Advanced Irrigation Engineering
18WLM242	Urban Flood Management	18WLM252	Wastewater Engineering & Management
18WLM243	Water Quality Modeling & Management	18WLM253	Ground Improvement Technique

Note:

1. Technical Seminar: CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any, and a senior faculty of the department. Participation in seminar by all postgraduate students of the same and other semesters of the programme shall be mandatory.

The CIE marks awarded for Technical Seminar, shall be based on the evaluation of Seminar Report, Presentation skill, Question and Answer session in the ratio 50:25:25.

2. Internship: All the students shall have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination will be conducted during III semester and prescribed credit shall be counted in the same semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as failed and have to complete during subsequent University examination after satisfy the internship requirements.

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III SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
				Theory	Practical/ Field work/ Assignment	Duration in hours	CIE Marks	SEE Marks	Total Marks	
1	PCC	18WLM31	Environmental Impact Assessment	04	--	03	40	60	100	4
2	PEC	18WLM32X	Professional elective 3	04	--	03	40	60	100	4
3	PEC	18WLM33X	Professional elective 4	04	--	03	40	60	100	4
4	Project	18WLM34	Evaluation of Project phase -1	--	02	--	100	--	100	2
5	Internship	18WLMI35	Internship	(Completed during the intervening vacation of I and II semesters and /or II and III semesters.)		03	40	60	100	6
TOTAL				12	02	12	**260**	**240**	**500**	**20**

Note: PCC: Professional core, PEC: Professional Elective

Professional elective 3		**Professional elective 4**	
Course Code under 18WLM32X	**Course title**	**Course Code under 18WLM33X**	**Course title**
18WLM321	Wetland management	18WLM331	Groundwater Assessment, Development & Management
18WLM322	Industrial Safety, Health , And Environmental Management	18WLM332	Spatial Planning and Regional Analysis
18WLM323	Industrial Waste Management & Audit	18WLM333	Global Warming and Climate Change

Note:

1. Project Phase-1: Students in consultation with the guide/co-guide if any, shall pursue literature survey and complete the preliminary requirements of selected Project work. Each student shall prepare relevant introductory project document, and present a seminar.
CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide and a senior faculty of the department.The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill and Question and Answer session in the ratio 50:25:25.
SEE (University examination) shall be as per the University norms.

2. Internship: Those, who have not pursued /completed the internship shall be declared as failed and have to complete during subsequent University examinations after satisfy the internship requirements.
Internship SEE (University examination) shall be as per the University norms.

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IV SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
				Theory	Practical/ Field work/ Assignment	Duration in hours	CIE Marks	SEE Marks Viva voce	Total Marks	
1	Project	18WLM41	Project work phase -2	--	04	03	40	60	100	20
			TOTAL	--	**04**	**03**	**40**	**60**	**100**	**20**

Note: Project: Project.

Note:

1. Project Phase-2:

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any and a Senior faculty of the department. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report subjected to plagiarism check, Project Presentation skill and Question and Answer session in the ratio 50:25:25.

SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

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

Subject Code	18WLM11	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
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. Dynamic programming	**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	**10 Hours**
Goal programming models with applications. Discrete differential dynamic programming and incremental dynamic programming - Linear decision rule models with application - Stochastic dynamic 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

Text Books:

1. S.D. Sharma: "Operations Research" KedaranathRamnath& Co. Meerut.
2. Rao,S.S. "Engineering Optimization",John Wiley & Sons,1996
3. Kanti Swarup, P.K. Gupta &Manmohan "Operations Research" Sultan Chand & Sons, 2014.

Reference Books:

1. H.A. Taha: "Operations Research" Macmilan publishing Co.
2. Ravindran,D.T.,Philips and Solberg,J.J."Operation Research- Principles and practice", Wiley Pub., 1987.
3. 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]

SEMESTER – I

Subject Code	18WLM12	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
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, Formation of precipitation, Climate and Weather seasons in India. Watershed concept and modeling: Catchment-topographic and ground water divide, Description of the catchment, catchment processes, demarking a catchment, stream patterns, water budgeting. Classification of models, model formulation, Lumped parameter conceptual models, Physically based models, Model performance testing.	**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, Factor affecting infiltration, Measurement, Horton's equation and Philip's equation. Infiltration indices, 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. Runoff:-Process, Factors affecting runoff, API, Basin yield, Curve number method.	**10 Hours**
Module -4	
Hydrograph and its features, Methods of hydrograph separation, Unit hydrograph and its derivation, Unit hydrographs from complex storms and for various durations, S-curve hydrograph and its uses, 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, Selection of design return period. 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.

Text Books:

1. Subramanya K."Engineering Hydrology", Tata McGraw Hill, 1998
2. Jaya Rami Reddy, P. "A text book of Hydrology", Laxmi publications,2009
3. Putty, M. R.Y. "Principles of Hydrology", I.K. Int. Publishing House, New Delhi,2010

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

DESIGN OF HYDRAULIC STRUCTURES

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

Subject Code	18WLM13	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

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.	**10 Hours**
Module -2	
Earthen Dam: Types, general principles of design, causes of failure, analysis of seepage through earth dams, stability analysis, control of seepage.	**10 Hours**

Module -3	
Spillway: Types, design criteria (ogee), energy dissipaters **Diversion Structures:** Types, causes of failure, Bligh's Theory and Khosla's Theory,	**10 Hours**
Module -4	
Design of Vertical Drop Weir. **Regulators**: Functions of cross/head regulator, alignment, Design of Cross Regulators.	**10 Hours**
Module -5	
Canal System: Canal networks, Kennedy's and Lacey's theory of canal design, Introduction to Canal fall and Canal Escapes.	**10 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.

Text Books:

1. Modi, P.N. "Irrigation, Water Resources and Water Power Engineering" Standard Book House, New Delhi, 2nd ed, 1990.
2. Garg S.K, Irrigation Engineering and Hydraulic Structures, Khanna Publishers N.D. 2006.

Reference Books:-

1. Varshney "Concrete dams"— Oxford & IBH Publications, 1978
2. Creager, Justin, Hinds. "Engineering for Dams (Volume-I, II and III)" – Wiley India Publications.

REMOTE SENSING & GEOGRAPHICAL INFORMATION SYSTEM

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

Subject Code	18WLM14	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
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:** **Remote Sensing Basic Principles:** Introduction, Electromagnetic Remote Sensing Process, Physics of Radiant Energy: Nature of Electromagnetic Radiation, Electromagnetic Spectrum**;** Energy Source and its Characteristics, Atmospheric Interactions with Electromagnetic Radiation: Atmospheric properties, Absorption of Ozone, Atmospheric effects on Spectral Response Patterns**;** Energy interactions with Earth's surface materials: Spectral Reflectance Curves; Cossine Law. **Remote Sensing Platforms and Sensors:** Satellite System Parameters, Sensor Parameter: Spatial Resolution, Spectral Resolution, Radiometric Resolution**;** Imaging Sensor Systems: Multispectral Imaging Sensor System, Thermal Sensing System, Microwave Imaging Systems; Earth Resources Satellites: Landsat Satellite Programme, SPOT Satellite, Indian Remote Sensing Satellite (IRS)**;** Meteorological Satellites: NOAA Satellite, GOES Satellite.	**10 Hours**
Module -2	
Visual Image Interpretation: Introduction **Digital Image Processing:** Introduction, Basic Character of Digital Image, Preprocessing: Geometric Correction Methods, Radiometric Geometric Correction, Atmospheric Geometric Correction**;** Image Enhancement Techniques: Contrast Enhancement**;** Spatial Filtering Techniques: Low Pass Filters, High Pass Filters, Filtering for Edge Enhancement**;** Image Transformations NDVI Transformation, PCA Transformation**;** Image Classification: Supervised Classification, Training Dataset, 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. Introduction: Maps and Map Scale, Map Scale, Type of Maps, Map and Glob **Geo-referencing and Projection:** Understanding Earth, Coordinate System, Map Projection, Transformation, Geo-referencing	**10 Hours**
Module -4	
Global Positioning System (GPS): Introduction. **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 , Geodatabase and Metadata	**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,	**10 Hours**

Local Methods of Interpolation Web GIS: Introduction, Web GIS, OGC & Web Services	

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.

Text Books:

1. M. Anji Reddy, 'Remote Sensing and Geographical Information Systems' 4th Edition, BS Publications.
2. Kang-Tsung Chang, 'Introduction to Geographic Information Systems', McGraw-Hill Book Company.

Reference Books:

1. Longley, P. A., Goodchild, M. F., Maguire, D. J., and Rhind, D. W., 'Geographic Information Systems and Science', 2nd Edition, John Wiley and Sons.
2. Burrough, P. A., and McDonnell, R. A. 'Principles of Geographical Information Systems', Oxford University Press, 2nd Edition.
3. Demers, M. N., 'Fundamentals of Geographic Information Systems', John Wiley & Sons, 3rd Edition.

WATER POLLUTION CONTROL

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

Subject Code	18WLM15	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
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 Sampling ,Water Acts, National Water Policy
- Effects of Industrial waste on water and land,
- Sources and estimation of point and non point sources of pollution.
- Geo-environmental Issues and management
- Water law ,Environmental Protection Law, legislation,
- Characterization of industrial Wastewater Pollutants.

Modules	Teaching Hours
Module -1	
Introduction: Definition of Water Pollution, Cause and Sources and Consequences of Water Pollution, Nature of pollutants, Ground water pollution and its effect, Water Act (1986), National Water Policy (CPCB). Water quality objectives and standards. **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. Effluent Standards and Stream Standards.	**10 Hours**
Module -2	
Wastewater & Monitoring : Existing approaches of control/abatement of water quality degradation, Material balance-methods of qualifications, Sampling: Grab Composite and Integrated Samples. **Monitoring:** Definition- Monitoring of stream, river , lake and its types, Continuous pH, Conductivity and Bio-monitoring. DO and BOD in streams, Transformation and transport processes, Oxygen transfer, Turbulent mixing, Flow augmentation. Surface and Ground Water quality monitoring, Water quality monitoring in river basins.	**10 Hours**
Module -3	
Point and Non-Point Source of Pollution: Point & Non – Point source pollution, Modeling approaches for modeling Point & non – point sources. **Surface and Ground Water quality modeling** – Modeling and Monitoring, types of water quality models, , Water quality control models, , 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, Water laws, legislation & Management: **Geo-environmental Issues -** Soil mineralogy characterization and its significance in determining soil behavior –Concepts of Saturated & unsaturated soil and its behavior – importance of Saturated & unsaturated soil in geo-environmental problems. Soil pollution & its effects, Soil pollution characteristics , Soil-water-contaminant interactions and its implications – Factors effecting retention and transport of contaminants. **Water laws & legislation** – riparian rights, Groundwater ownership, Environmental Protection Law, Water pollution control acts and legislation, Legislation in India, Control Acts.	**10 Hours**

Module -5

Characterization of industrial Wastewater Pollutants:	**10 Hours**
Characterization of industrial Wastewater Pollutants of Nuclear Power Plants, Thermal Power Plants, Industries: Fertilizer, Tannery, Pulp, and Paper Mill and Pharma- Canticle Industries	

Course outcomes:

On completion of this course, students are able to

- Understand Wastewater characterization & Monitoring, Water Acts, Water laws & legislation.
- Evaluate the Impact of industrial waste effects.
- Understand the various sources of pollution and its effects.
- Understand Effluent Standards and Stream Standards, sampling.
- Estimate and impacts of Point and non point sources of pollution.
- Surface and Ground Water quality modeling, Geo-environmental Issues and management
- Characterization of industrial Wastewater Pollutants.

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.

Text Book:

1. H.S. Peavy, D.R. Rowe, G. Tchobanoglous. Environmental Engineering, Mcgrow-Hill International Edition, 1st Edition, 2013.
2. Dr. B.C. Punmia, Arun Kumar Jain, Ashok Kumar Jain. Environmental Engineering II, Laxmi Publications Pvt Limited, 2005.

Reference Books:

1. Metcalf and Eddy, A Text Book of Waste Water Engineering
2. Sparks, D.L., "Environmental Soil Chemistry" Academic Press, New York, 2002.
3. Alvarez-Benedi J. and Munoz-Carpena, R., "Soil-Water-Solute Process Characterization: An Integrated Approach" CRC Press, New York, 2005.

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

Subject Code	18WLML16	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
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 given two experiment to do in the examination.
3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks
4. Experiment 1: Procedure + Conduction + Viva: **08 + 14 +08 (30)**
Experiment 2: Procedure + Conduction + Viva: **08 + 14 +08 (30)**
5. Change of experiment is allowed only once and Marks for the procedure for the alternate experiment is not given.

RESEARCH METHODOLOGY AND IPR

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

Course Code	18RMI17	CIE Marks	40
Number of Lecture Hours/Week	02	Exam Hours	03
Total Number of Lecture Hours	25	SEE Marks	60

Credits - 02

Course objectives:

- To give an overview of the research methodology and explain the technique of defining a research problem
- To explain the functions of the literature review in research.
- To explain carrying out a literature search, its review, developing theoretical and conceptual frameworks and writing a review.
- To explain various research designs and their characteristics.
- To explain the details of sampling designs, and also different methods of data collections.
- To explain the art of interpretation and the art of writing research reports.
- To explain various forms of the intellectual property, its relevance and business impact in the changing global business environment.
- To discuss leading International Instruments concerning Intellectual Property Rights.

Module-1		**Teaching Hours**
Research Methodology: Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research, and Problems Encountered by Researchers in India. ■		**05**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	
Module-2		
Defining the Research Problem: Research Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration. **Reviewing the literature:** Place of the literature review in research, Bringing clarity and focus to your research problem, Improving research methodology, Broadening knowledge base in research area, Enabling contextual findings,		**05**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	
Module-3		
Research Design: Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs, Important Experimental Designs. **Design of Sample Surveys:** Introduction, Sample Design, Sampling and Non-sampling Errors, Sample Survey versus Census Survey, Types of Sampling Designs.		**05**

Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	
Module-4		
Data Collection: Experimental and Surveys, Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method. **Interpretation and Report Writing:** Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports		**05**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
Module-5		
Intellectual Property: The Concept, Intellectual Property System in India, Development of TRIPS Complied Regime in India, Patents Act, 1970, Trade Mark Act, 1999,The Designs Act, 2000, The Geographical Indications of Goods (Registration and Protection) Act1999, Copyright Act,1957,The Protection of Plant Varieties and Farmers' Rights Act, 2001,The Semi-Conductor Integrated Circuits Layout Design Act, 2000, Trade Secrets, Utility Models, IPR and Biodiversity, The Convention on Biological Diversity (CBD) 1992, Competing Rationales for Protection of IPRs, Leading International Instruments Concerning IPR, World Intellectual Property Organisation (WIPO),WIPO and WTO, Paris Convention for the Protection of Industrial Property, National Treatment, Right of Priority, Common Rules, Patents, Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition, Patent Cooperation Treaty (PCT), Advantages of PCT Filing, Berne Convention for the Protection of Literary and Artistic Works, Basic Principles, Duration of Protection, Trade Related Aspects of Intellectual Property Rights(TRIPS) Agreement, Covered under TRIPS Agreement, Features of the Agreement, Protection of Intellectual Property under TRIPS, Copyright and Related Rights, Trademarks, Geographical indications, Industrial Designs, Patents, Patentable Subject Matter, Rights Conferred, Exceptions, Term of protection, Conditions on Patent Applicants, Process Patents, Other Use without Authorization of the Right Holder, Layout-Designs of Integrated Circuits, Protection of Undisclosed Information, Enforcement of Intellectual Property Rights, UNSECO.		**05**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

Course outcomes:

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

- Discuss research methodology and the technique of defining a research problem
- Explain the functions of the literature review in research, carrying out a literature search, developing theoretical and conceptual frameworks and writing a review.
- Explain various research designs and their characteristics.
- Explain the art of interpretation and the art of writing research reports
- Discuss various forms of the intellectual property, its relevance and business impact in the changing global business environment and leading International Instruments concerning IPR.

Graduate Attributes (As per NBA): Problem analysis, Investigation, Design, Individual and teamwork, Communication skills, Professionalism.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.

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

Textbooks

1	Research Methodology: Methods and Techniques	C.R. Kothari, Gaurav Garg	New Age International	4th Edition, 2018
2	ResearchMethodologyastep-by-stepguideforbeginners. (For the topic Reviewing the literature under module 2)	Ranjit Kumar	SAGE PublicationsLtd	3rd Edition, 2011
3	Study Material (For the topic Intellectual Property under module 5)	Professional Programme Intellectual Property Rights, Law and Practice, The Institute of Company Secretaries of India, Statutory Body Under an Act of Parliament, September 2013		

Reference Books

1	Research Methods: the concise knowledge base	Trochim	Atomic Dog Publishing	2005
2	Conducting Research Literature Reviews: From the Internet to Paper	Fink A	Sage Publications	2009

WATERSHED MANAGEMENT [As per Choice Based Credit System (CBCS) scheme] SEMESTER – II			
Subject Code	18WLM21	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
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, Watershed characteristics, Deterioration of watershed, Watershed delineation, Prioritizing watersheds, Coding of watershed, Morphometric analysis of watershed-Linear, Rreal and Relief aspects, Channel networks, Hypsometric analysis.	**10 Hours**
Module -2	
Sediment transport: Sediment-Sources, Mechanics of sediment transport, factors affecting sediment yield, Types of sediment load, Estimation of bed load and suspended sediment load. Estimation of bed load using sampler. Distribution of suspended load and estimation of suspended load, Selection of sediment sampling point, Frequency of sampling, Location of sediment observation post, 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, Soil moisture, Ground water, 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, Land capability rating table, Identification of classes in the field, Land use capability classification, Recommended land use and Soil conservation practices for all capability classes. Erosion control measures in agriculture land: Importance, Contour bunding, Drainage of excessive water, 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	**10 Hours**

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 structure, Retaining walls, Gully and Ravine reclamation.	
Module -5	
Watershed Management: Introduction, Watershed characteristics, Causes and Consequences of watershed deterioration, Objectives, People's participation-Definition, 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.

Text Books:

1. Tideman, E. M., "Watershed Management", Omega Scientific Publishers, New Delhi,2002
2. Suresh Rao, Soil and Water Conservation Practices, Standard Publishers, 2003.
3. J. V. S Murthy, Watershed Management, New Age International Publishers, 1998.

Reference Books:

1. Heathcote, I. W., "Integrated Watershed Management" Springer.
2. Strahler, A. H.,"Modern physical geography", John Wiley & Sons, 1991.
3. V.V. N. Murthy, Land and Water Management, Kalyani Publishers, 1994.

GROUND WATER HYDROLOGY

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

Subject Code	18WLM22	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
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.

Text Books

1. A. K. Rastogi., Numerical Groundwater Hydrology, Penram International Publishing (India) Pvt.Ltd.2007.

Reference Books:

1. Todd D.K. & Mays, L.W., "Ground Water Hydrology", 3 Ed, Wiley.
2. Raghunath H.M., "Ground Water", New Age Publishers, 2007.

SOLID WASTE ENGINEERING AND MANAGEMENT
[As per Choice Based Credit System (CBCS) scheme]

Subject Code	18WLM23	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
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.	**10 Hours**

Processing Techniques- Mechanical Volume Reduction, Thermal Volume Reduction, Manual Component Separation.	
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.	
Text Books: 1. Tchobanoglous G., Theissen H., and Eliassen R., "Solid Waste Engineering Principles and Management Issues", McGraw Hill, New York. 2. H.S. Peavy, D.R. Rowe, G. Tchobanoglous. Environmental Engineering, Mcgrow-Hill International Edition, 1st Edition, 2013. **Reference Books:** 1. Mantel C. L.,(1975), "Solid Waste Management", John Wiley 2. Pavoni J.L., "Handbook of Solid Waste Disposal".	

ADVANCED REMOTE SENSING [As per Choice Based Credit System (CBCS) scheme] SEMESTER – I			
Subject Code	18WLM241	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03
CREDITS – 04			

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 **Introduction:** Definition of terms, Concepts and types of remote sensing; evolution of remote sensing technology, stages in remote sensing technology, spatial data acquisition, interdisciplinary nature and relation with other disciplines, applications of remote sensing, advantages of RS over conventional methods of survey and inventorying, Overview of RS	**10 Hours**
Module -2	
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.	**10 Hours**
Module -3	
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 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.	**10 Hours**
Module -4	
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	**10 Hours**

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.	
Module -5	
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.	**10 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.	
Text Books 1. George Joseph, "Fundamentals of Remote Sensing", Universities Press, 2005 2. P. J. Curran, "Physical aspects of Remote Sensing", Longman Group Limited, London.	
References Books: 1. F. F. Sabins, "Remote Sensing Principles and Interpretation", Waveland Press. 2. John R Jensen "Introductory Digital Image Processing: A Remote Sensing Perspective", Pearson Series Geographic Information Science, ISBN- 13: 978-0134058160 3. Robert A. Schowengerdt "Remote sensing Models and methods for image processing",Second edition, 1997, Academic Press.	

URBAN FLOOD MANAGEMENT

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

Subject Code	18WLM242	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

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.	**10 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	**10 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	**10 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	**10 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.	**10 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.

Text Books:

1. Chris Zevenbergen, Adraian Cashman, Erik Pasche and Richard Ashely. "Urban Flood Management", CRC Press-2010 Edition
2. Richard Ashley, Stephen Garvin, Erik Pasche, Andreas Vassilopoulos, Chris Zevenbergen. "Advances in Urban Flood Management" CRC Press-2007 Edition.

Reference Books:

1. 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).
2. Arun Kumar. "Handbook of Flood Management: Flood Risk Simulation, Warning, Assessment and Mitigation", SBS Publisher, India, Vol. 1 2009.

WATER QUALITY MODELLING AND MANAGEMENT

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

Subject Code	18WLM243	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03
CREDITS – 04			

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.	**10 Hours**

Module -2	
River and streams, convective diffusion equation and its applications, estuaries, estuarine hydraulics, estuarine water quality models. Lakes and reservoirs.	**10 Hours**
Module -3	
Contaminant transport in unsaturated variable soils, contaminant transports in ground water advection, dispersion, one dimensional transport with linear absorption	**10 Hours**
Module -4	
Dual porosity models, numerical models, bio-degradation reaction. Water quality management, socio-economic aspects of water quality management.	**10 Hours**
Module -5	
Management alternatives for water quality control, waste load allocation process. Lake quality management, ground water remediation.	**10 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.

Text 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

Reference Books:

1. Jerald L. Schnoor, “Environmental Modelling”. Publisher: John Wiley and Sons Ltd, 1996, ISBN:9780471124368
2. Thomann, “Systems Analysis and Water Quality Management”. McGraw-Hill Inc.,US, ISBN-13: 978-0070642140
3. A. K. Rastogi, “Numerical Groundwater Hydrology”, International Publishing (India)
   1. Pvt. Ltd. (2007).

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

Subject Code	18WLM251	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
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:** Necessity, Advantages and Disadvantages, Types & Techniques of Irrigation including advanced techniques, Irrigation Development in India. Soil-Moisture Irrigation Relationship, 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: in relation to soil characteristics and irrigation practices, 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, Duty & delta of crops, Irrigation scheduling, Consumptive use of Crop- Blanney-Criddle, Thornthwait penman, Christiansen methods, Water-use efficiency, scope of computerization in irrigation	**10 Hours**
Module -4	
Water conveyance and application Lined and unlined channels- designs, seepage losses, 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: Methods of pricing irrigation water, Economic water rates, Introduction to Optimization techniques- 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.

Text Books:

1. Modi. P. N., Irrigation, Water Resources & Water Power Engineering- Standard Publishers, New Delhi
2. B. C. Punmia, Pande, Ashok kumar and Arunkumar Jain "Irrigation and water power engineering" Laxmi Publications (P) LTD.
3. Chaturvedi. M.C, "Water Resources Systems Planning and Management", Tata McGraw Hill. NY

Reference Books:

1. Linsley, R. K. and Frazinini, J. B.,-"Water Resources Engineering"2nd Ed. McGraw Hill, NY
2. James L.D and Lee R.R. "Economics of Water Resources Systems Planning" McGraw Hill. NY

WASTEWATER ENGINEERING & MANAGEMENT
[As per Choice Based Credit System (CBCS) scheme]

Subject Code	18WLM252	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

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.	**10 Hours**
Module -2	
Theoretical principles and design: Screens, equalization basin, grit chamber, primary and secondary settling tanks.	**10 Hours**
Module -3	
Theoretical principles and design: Suspended growth system - conventional activated sludge process and its modifications. Attached growth system – trickling filter, bio-towers and rotating biological contactors. Principles of stabilization ponds.	**10 Hours**
Module -4	
Advanced Wastewater Treatment: Need and technologies used. Nitrification and Denitrification Processes, Phosphorous removal. Wastewater disinfection.	**10 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.	**10 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.

Text Books:

1. Metcalf and Eddy Inc., "Wastewater Engineering - Treatment and Reuse", 4th Edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
2. Karia G.L., and Christian R.A., "Wastewater Treatment Concepts and Design Approach" , Prentice Hall of India Pvt. Ltd., New Delhi.
3. Ronand L., and Droste, "Theory and Practice of Water and Wastewater Treatment", John Wiley and Sons Inc.

Reference Books:

1. Benefield R.D., and Randal C.W., "Biological Process Design for Wastewater Treatment", Prentice Hall, Englewood Chiffs, New Jersey.
2. Lee C.C., and Lin S.D., "Handbook of Environmental Engineering Calculations", McGraw Hill, New York.
3. "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	18WLM253	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

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	**10 Hours**
Module -2	
Hydraulic modifications: dewatering systems, filtration, drainage and seepage control with geosynthetics, preloading and vertical drains, electro-kinetic dewatering.	**10 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.	**10 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.	**10 Hours**
Module -5	
Geosynthetic materials: functions, property characterization, testing methods for geosynthetic materials, geotextiles, geomemberanes, geogrids, geonets and geocells.	**10 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.

Text Books:

1. Purushotham Raj, Ground Improvement Techniques, Laxmi publications, New Delhi.
2. Hausmann, M. R., “Engineering principles of ground modification”, McGraw –Hill Pub.Co.Newyork,1990.
3. Koener R.M., “Construction and Geotechnical Methods in Foundation Engineering”, McGraw Hill Pub. Co., New York, 1985.

Reference Books:

1. Ingles O.G. and Metcalf J.B., “Soil Stabilization processes and practice”, Butterworths, London, 1972.
2. Koerner R.M., “Designing with Geosynthetics”, Prentice Hall Pub.1994.
3. Bell F.G., “Ground Engineer’s Reference Book”, Butterworths, London, 1987.

COMPUTATIONAL LABORATORY

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

SEMESTER – II

Subject Code	18 WLM L26	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	42	Exam Hours	03

CREDITS – 02

Course objectives:

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

Topics	**Teaching Hours**
GIS Application 1. Introduction to QGIS 2. Map registration/ Geo-referencing 3. Digitization 4. Map projection 5. ER Diagram 6. Design of Geo-database 7. Interpolation and Buffering 8. Image Classification-Supervised 9. Image Classification- UnSupervised 10. Watershed Delineation	**42 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. **Experiment 1**: Procedure + Conduction + Viva: **08 + 14 +08 (30)**
   Experiment 2: Procedure + Conduction + Viva: **08 + 14 +08 (30)**
5. **Change of experiment is allowed only once and Marks for the procedure for the alternate experiment is not given.**

TECHNICAL SEMINAR [As per Choice Based Credit System (CBCS) scheme]			
Subject Code	18WLM27	IA Marks	40
Number of Practical/ Field Work/ Assignments	02	Exam Marks	60
Total Number of Lecture Hours	24	Exam Hours	3
CREDITS – 02			

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 have to present seminar atleast two times on the selected topic 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 responsibility of the student and guide/staff-in-charge to take care of plagiarism.

Marks Distribution: Literature Survey + Presentation (PPT) + Report + Question & Answer: 25 + 30 + 30 + 15; (=100).

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

Subject Code	18 WLM31	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
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: Assessment and Prediction of Impacts of Biological Environment, Cultural and Socio-economic Environment, Rapid and Comprehensive EIA, EIA Regulations in India, Public Participation	**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.

Text Books:

1. L. W. Canter, Environmental Impact Assessment, 2nd Ed., McGraw-Hill, 1996
2. Y. Anjaneyulu, ValliManickam. "Environmental Impact Assessment Methodologies", CRC Press, 2011

Reference Books:-

1. 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.
2. 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	18 WLM321	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

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.	**10 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.	**10 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.	**10 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.	**10 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.	**10 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.

Text Books:

1. William J. Mitsch, James G. Gosselink, "Wetlands", Published by John Wiley and sons, Inc., Hoboken, New Jersy, Canada
2. Falconer, R. A and Goodwin, P (Ed), "Wetland Management", 1994, Thomas Telford, London.

References:

1. Bruce E. Hammer., "Constructed Wetlands for Wastewater Treatment", 1989, CRC-Press; I Ed.
2. Verhoeven, J.T.A., Beltman, B., Bobbink, R., Whigham, D.F. (Eds.). "Wetlands and natural resource management", Springer-Verlag Berlin Heidelberg, 2006.

INDUSTRIAL SAFETY, HEALTH , AND ENVIRONMENTAL MANAGEMENT
[As per Choice Based Credit System (CBCS) scheme]

Subject Code	18WLM322	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: The course is designed to train students:

- To have through knowledge about occupational health, industrial hygiene, accidental prevention techniques
- To make the student aware about safety auditing and management systems, pollution prevention techniques etc.
- To Learn about risk assessment and management.
- To identify risks, link to individual behaviors, evaluate precautions and preparations, identify correct processes and procedures, identify critical points, & also improve decision making.

Modules	Teaching Hours
Module -1 Occupational Safety and Health Management : **Introduction:** Occupational Safety and Health Act, Occupational Safety and Health Administration, Right to know Laws. **Indian Acts** – Labour Act, Factories Act,OSHA **Occupational Health Hazards**, Promoting Safety, Safety and Health training, Stress and Safety, Health and Safety Considerations, Personal Protective Equipment	**10 Hours**
Module -2 Radiation and Industrial Hazards	
Radiation -Types and effects of radiation on human body, Measurement and detection of radiation intensity. Effects of radiation on human body, Measurement – disposal of radioactive waste, Control of radiation **Industrial noise -**Sources, and its control, Effects of noise on the auditory system and health, Measurement of noise , **Different air pollutants in industries**, Effect of different gases and particulate matter ,acid fumes ,smoke, fog on human health **Vibration** - effects, measurement and control measures **Industrial Hygiene.**	**10 Hours**
Module -3 Electrical, Fire Hazards & safety	
Electrical Hazards Safe limits of amperages, voltages, distance from lines, etc., Joints and connections, Overload and Short circuit protection, Earthing standards and earth fault protection , Protection against voltage fluctuations, Effects of shock on human body Hazards from Borrowed nutrals, Electrical equipment in hazardous atmosphere, Criteria in their selection, installation, maintenance and use, Control of hazards due to static electricity, **Fire and other Hazards** General causes and classification of fire, Detection of fire, extinguishing methods, fire fighting installations with and without water. Machine guards and its types, automation. High pressure hazards, safety, emptying, inspecting,	**10 Hours**

repairing, hydraulic and nondestructive testing.	
Module -4 Ergonomics & Accident	
Ergonomics: Introduction, Definition, Objectives, Advantages. **Ergonomics Hazards** - Musculoskeletal Disorders and Cumulative Trauma Disorders need, Task Analysis, Preventing Ergonomic Hazards, Ergonomics Programme. **Accident** – Causation, investigation methods and different models	**10 Hours**
Module -5 Occupational Hazard and Control	
Hazard Analysis, Human Error and Fault Tree Analysis, Emergency Response. Hazards and their control in different manufacturing and processing industries. **Importance of Industrial safety**, role of safety department, Safety committee and Function. **Health problems in different types of industries** –Textile, steel and food processing, pharmaceutical, Tannery , Cement , Dairy , Paper and Pulp, canning industry. occupational Health and Safety considerations in Wastewater Treatment Plants.	**10 Hours**

Course outcomes:

On completion of this course, students are able to

- Contribute to the development and maintenance of a healthy and safe work environment
- Interpret and apply legislative requirements, industry standards, and best practices in a variety of workplaces
- Apply risk management principles to anticipate, identify, evaluate and control physical, chemical, biological and psychosocial hazards
- Collect, manage, and interpret information and data to identify trends and issues in the workplace
- Design, support, and evaluate health and safety programs and implement procedures using project management principles and processes appropriate to the task
- Affect/manage change by advancing OH&S principles within management systems, cultures, practices, and priorities.

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.

Text Books :

1. R.K.Jain and Sunil S.Rao , I**ndustrial Safety , Health and Environment Management Systems,** Khanna publishers , New Delhi (2006)

2. Slote.L,Handbook of **Occupational Safety and Health**, John Willey and Sons, NewYork .

Reference Books:

1.Goetsch D.L., "**Occupational Safety and Health for Technologists**", Engineers and Managers", Prentice Hall.

2. Heinrich H.W., **"Industrial Accident Prevention",** McGraw Hill Publication , Newyork.
3. Colling D.A., "**Industrial Safety Management and Technology**", Prentice Hall, New Jersey.

INDUSTRIAL WASTE MANAGEMENT AND AUDIT
[As per Choice Based Credit System (CBCS) scheme]

Subject Code	18 WLM323	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

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.	**10 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	**10 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.	**10 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 radioactive techniques for wastewater treatment. **Bio-**	**10 Hours**

Remediation of contaminated soils	
Module -5	
Environmental Auditing: Introduction, Cost of Pollution, Importance of Environmental audit and solutions, Financial and Managerial opportunities.	**10 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.

Text Books:

1. Eckenfelder, "Industrial Water pollution Control"- McGraw hill Company, New Delhi American Chemical Society, Washington D.C. USA
2. Nemerow N.N., "Liquid Waste of industry theories, Practices and Treatment". Addison Willey New York.
3. Mahajan," Pollution control in Process industries". TMH, New Delhi.

Reference Books

1. Azad N. S., "Industrial Wastewater Management Hand Book" McGraw Hill book Co., New York.
2. Ross R.D. "Industrial Waste Disposal", Reinhold Environmental Series – New York.
3. Dickinson" Practical Waste Treatment and Disposal Applied Science publication, London.

GROUNDWATER ASSESSMENT, DEVELOPMENT AND MANAGEMENT

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

Subject Code	18 WLM331	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03
CREDITS – 04			

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.	**10 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.	**10 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.	**10 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	**10 Hours**
Module -5	
Groundwater Basin Management and Conjunctive Use: Groundwater Basin Management, Conjunctive Use, Mathematical modelling of a dual aquifer system.	**10 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.

Text Books:

1. K. R. Karanth, Ground Water Assessment Development and Management, Tata McGraw-Hill Publishing Company Limited, New Delhi.1.

Reference Books:

1. David Keith Todd, Groundwater Hydrology, Gopsons Paper Ltd., Noida, Second Edition.
2. H. M. Raghunath, Ground Water, New Age International (P) Ltd., New Delhi, Third Edition.

SPATIAL PLANNING AND REGIONAL ANALYSIS
[As per Choice Based Credit System (CBCS) scheme]

Subject Code	18WLM332	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03
CREDITS – 04			

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	**10 Hours**
Module -2	

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,.	**10 Hours**
Module -3	
Regional Planning (Continued): Policy Maker and Citizen Input into the Classical Planning Process:- Ideal Sequence, Shortcut and Recycling within Planning Process **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,	**10 Hours**
Module -4	
Regional Analysis (Continued): 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.	**10 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.	**10 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.	

Text 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

Reference books:

1. Harmit Singh Bedi, Smart Urban and Rural Planning Techniques, COPAL Publication, 2015.
2. Kang-Tsung Chang, 'Introduction to Geographic Information Systems', McGraw-Hill Book Company.

GLOBAL WARMING AND CLIMATE CHANGE

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

Subject Code	16WLM333	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 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: Introduction and history of meteorology and climatology: The atmosphere, Solar energy, Global circulation, , Climatology, Mid-latitude disturbances , The polar regions, Tropical weather, Paleoclimates, The global climate system **Atmospheric composition, mass and structure** **Composition of the atmosphere:** Primary gases, Greenhouse gases, Reactive gas species, Aerosols, Variations with height, Variations with latitude and season, Variations with time **Mass of the atmosphere:** Total pressure, Vapor pressure	**10 Hours**
Module -2	
Atmospheric composition, mass and structure **The layering of the atmosphere:** Troposphere, Stratosphere, Mesosphere, Thermosphere, Exosphere and magnetosphere **Solar radiation and the global energy budget :** Solar radiation : Solar output, Terrestrial infrared radiation and the greenhouse effect, Heat budget of the earth	**10 Hours**

Atmospheric moisture budget : The global hydrological cycle, Humidity, Evaporation, Condensation, Precipitation characteristics and measurement	
Module -3	
Numerical models of the general circulation, climate and weather prediction Fundamentals of the GCM, Model simulations: GCMs, Simpler models, Regional models, Data sources for forecasting, Numerical weather prediction: Short- and medium- range forecasting, Nowcasting, Long-range outlooks.	**10 Hours**
Module -4	
Boundary layer climates Surface energy budgets, Non-vegetated natural surfaces : Rock and sand, Water, Snow and ice Vegetated surfaces: Short green crops, Forests Urban surfaces: Modification of atmospheric composition, Modification of the heat budget, Modification of surface characteristics, Tropical urban climates.	**10 Hours**
Module -5	
Climate change: General considerations, Climate forcing, feedback and response : Climate forcing, Climate feedbacks, Climate response, The importance of framework **The climatic record :** The geological record, The last glacial cycle and post-glacial conditions, The past 1000 years **Understanding recent climatic change :** Circulation changes, Solar variability, Volcanic activity, Anthropogenic factors **Projections of temperature change through the twenty-first century :** Applications of General Circulation Models, The IPCC simulations **Projected change in other system components :** Hydrologic cycle and atmospheric circulation, Global sea level, Snow and ice, Vegetation, Postscrip	**10 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.

Text Books:

1. Barry R.G., and Chorley R.L., “Atmosphere, Weather and Climate”, 4th Edition, ELBS Publication.
2. Bolin B., (Ed.), “Carbon Cycle Modelling”, John Wiley and Sons Publications.

Reference Books:

1. Srivatsava A.K., “Global Warming”, APH Publications.
2. Wyman R.L., (Ed.), , “Global Climate Change and Life on Earth”, Chapman and Hall Publications.
3. Yadav, Chander and Bhan, “Global Warming: India’s Response and Strategy”, RPH Publications.