DELHI TECHNOLOGICAL UNIVERSITY

M.Tech. (Environmental Engineering)

SCHEME & SYLLABUS

2025

DELHI TECHNOLOGICAL UNIVERSITY

SCHEME OF TEACHING AND EVALUATION

MASTER OF TECHNOLOGY IN ENVIRONMENTAL ENGINEERING (ENE)

Semester-I

S. No.	Course Code	Course Title	Type	Cr	L	T	P	Total Credits
1.	ENE501	Water and Waste Water Engineering & Design	Core	4	3	0	2	**24**
2.	ENE503	Air Pollution & Control	Core	4	3	0	2	
3.	ENE505	Environmental Impact Assessment	Core	4	3	1	0	
4.	ENE507	Environmental Chemistry and Microbiology	Core	4	3	0	2	
5.	ENE511	Global Warming & Climate Change	Departmental Elective - 1	4	3	1	0	
	ENE513	Planning and Design of Environmental Services		4	3	1	0	
	ENE515	Industrial Waste Management		4	3	1	0	
6.	ENE551	Seminar	Self-Study / MOOC	2				
	ENE553	MOOC		2				
7.	ENE541	Occupational Health & Safety (Option 1)/ Environmental Testing & Analysis (Option 2)	Skill Enhancement Course - 1	2	2	0	0	
8.	UEC5YY	Audit Course		0				

Semester – II								
S. No.	**Course Code**	**Course Title**	**Type**	**Cr**	**L**	**T**	**P**	**Total Credits**
9.	ENE502	Water Resources and Environmental Hydraulics	Core	4	3	1	0	**24**
10.	ENE504	Solid Waste Management	Core	4	3	0	2	
11.	ENE520	Environmental Monitoring & Assessment	Departmental Elective - 2	4	3	0	2	
	ENE522	Design of Hydraulic Structures		4	3	1	0	
	ENE524	Waste Containment & Remediation		4	3	1	0	
12.	ENE530	Environmental Modelling and Risk Assessment	Departmental Elective - 3	4	3	0	2	
	ENE532	Bioremediation		4	3	1	0	
	ENE534	Remote Sensing & GIS		4	3	0	2	
13.	UCC502	Research Methodology and IPR		4				
14.	ENE540	Industrial Training	Industrial Training / Skill Enhancement Course - 2	4				
	ENE542	Operation of Sewage Treatment Plants (STPs) and Effluent Treatment Plants (ETPs)		4				
Semester-III								
15.	ENE601	Environmental Management & Sustainable Development	Core	4	3	1	0	16
16.	OEN601	Green Technology & Sustainability	Open Elective 1	4	3	1	0	
17.	ENE603	Minor Project/Research Thesis/Patent		8				

Semester-IV								
18.	ENE602	Major Project/ Research Thesis/Patent	16					16

SEMESTER 1

ENE501– Water and Waste Water Engineering & Design			
Teaching Scheme **Credit: 4**	**L**	**T**	**P**
	3	0	2

Course Outcomes: At the end of this course, students will be able to:

1. Gain enhanced knowledge of Physical, chemical, biological properties of water & waste water.
2. Understand the design of various unit processes/operations provided in water treatment plants and design of water distribution systems.
3. Understand/ Develop the design of sewer.
4. Understand the Concept of Common Effluent Treatment Plants.
5. Understand/Analyze the kinetics of reactor & reactor design

Unit 1: Water and wastewater quality parameters; Eutrophication and thermal stratification in lakes; River pollution - Oxygen sag curve.
Unit 2: Water treatment methods - screening, sedimentation with and without coagulation, filtration, desalination, disinfection; Water distribution and storage
Unit 3: Point and non-point sources of wastewater; Population forecasting methods; Design of sewer and storm water sewers; Sewer appurtenances; Preliminary, primary, secondary and tertiary sewage treatment; Sludge generation, processing and disposal methods; Sewage farming.
Unit 4: Sources and characteristics of industrial effluents; Concept of Common Effluent Treatment Plants (CETP); Wastewater recycling and zero liquid discharge.
Unit 5: Kinetics and reactor design: Mass and energy balance, Order and rate of reactions, Batch reactors, completely mixed flow reactors, Plug flow reactors.

References:

1. Peavy, Rowe and Tchobanoglous: Environmental Engineering
2. Garg, S.K., Water Supply Engineering- Vol-I, Khanna Publishers, New Delhi.
3. Punmia, B. C. : Water Supply and Wastewater Engineering, Laxmi Publications
4. Steel, E.W, and Mc Ghee, T.J., Water Supply and Sewerage. Mc Graw Hill Book Co., New York.
5. Birdie: Water Supply and Sanitary Engineering, Standard Publishers Distributors.
6. Manual on Sewerage and Sewage disposal-CPHEEO, Govt. of India.
7. Metcalf and Eddy, Wastewater Engineering: Treatment, disposal, and reuse. TMH, New Delhi.
8. Wastewater Treatment Concept and design approach – G.L. Karia and R.A. Christian, PHI Publications
9. Fiar, G.M., and Geyer, J.C., Water and Wastewater engineering, Vol-I & II, John Wiley and sons, New York.
10. Anaerobic Sewage treatment by Van Haandel and Lettinga, John Wiley & Sons Publication
11. Eckenfelder, Activated sludge treatment of industrial wastewater
12. Hammer, M.J., Water and Wastewater Technology. John Wiley and sons-Inc, New York.

ENE503 – Air Pollution & Control			
Teaching Scheme **Credit: 4**	**L**	**T**	**P**
	3	0	2

Course Outcomes: At the end of this course, students will be able to:

1. Understand the fundamentals of air pollution, their sources and effects.
2. Analyse the air quality data.
3. Evaluate the efficiency of air pollution control equipment.
4. Predict / Estimate concentration at any point downwind of the emission source.
5. Develop air and noise pollution control management plan

Unit 1: Introduction Definition, Sources of air pollution, Different pollutants (Gaseous and particulate), air pollution sampling & measurement for gaseous and particulates, effects of air pollution. air quality standards
Unit 2: Air Pollution & Meteorology Concept of atmosphere, wind movements, wind rose diagram, different meteorological parameters impacting pollutant concentration, Measurement of meteorological parameters, Atmospheric lapse rate, Adiabatic lapse rate, Atmospheric classification, Plume behaviour, Plume rise equation, Gaussian Plume Dispersion equation
Unit 3: Air Pollution Control Equipment Control of gaseous and particulate matter, Settling chambers. Inertial devices, electrostatic precipitator, scrubbers, fitters, absorption, absorption, adsorption devices, combustion devices, condensation devices
Unit 4: Legislations & Air Quality Index Air pollution legislation, Automobile emission and standards, Air pollution episodes, Air quality index, Indoor air pollution
Unit 5: Noise Pollution Basics of acoustics, sound power, sound intensity, sound pressure level, measurement of noise, noise mapping, noise standards, health effects of noise, basic knowledge about noise models, noise control methods.

References:

1. Rao CS, Air Pollution and Control, New Age International Pvt Ltd
2. Rao and Rao, Air Pollution Control Engineering, McGraw Hill Education
3. KL Dorean, Air Pollution, CBS Publishers and Distributors Pvt Ltd. ISBN: 978-81-239-2901-9
4. JR Mudakavi, Principles and Practices of Air Pollution Control and Analysis, I.K. International Publishing House Pvt. Ltd. ISBN: 978-93-80026-38-1
5. Stern C., Fundamentals of Air Pollution (1984), Academic Press, ISBN: 978-0126665802

ENE505 – Environmental Impact Assessment			
Teaching Scheme **Credit: 4**	**L**	**T**	**P**
	3	1	0

Course Outcomes: At the end of this course, students will be able to:

1. Identify the environmental attributes to be considered for the EIA study
2. Understand a variety of professional tools used in predicting environmental impacts.
3. Evaluate the methodology to prepare EIA.
4. Formulate the methodology for Environmental Auditing.
5. Develop their own perspectives on impact assessment and able to relate this to other subject areas

Unit 1: Introduction Definition and history of environmental impact assessment, related law necessary for EIA, Objectives of Environmental Impact Assessment, MoEFCC notifications on EIA.
Unit 2: Process for EIA, TOR, IEE, Components of EIA Reports; Tools for assessment of environmental impacts: checklist, networks, matrices, overlays, baseline study, scoping & scales, network overlays, index methods.
Unit 3: Planning of environmental Factors; Prediction and assessment of impacts on air and noise; soil and land use; water quantity and quality.
Unit 4: Mitigation and Monitoring process for environmental impact assessment; Environmental Auditing, Impact Analysis of Pulp and Paper Industry, Thermal Power Plants, Case Studies on EIA.

References:

1. Canter L, Environmental Impact Assessment, McGraw Hill 2014
2. John Glasson, John Glasson, Riki Therivel, Riki Therivel, Andrew Chadwick, Introduction to Environmental Impact Assessment by J. Glasson, eBook ISBN9780203023068
3. Noble B, Introduction to Environmental Impact Assessment: A Guide to Principles and Practice, Oxford University Press 2015
4. Shrivastava AK, Environment Impact Assessment, APH *Publishing* Corporation

ENE507 – Environmental Chemistry and Microbiology			
Teaching Scheme **Credit: 4**	**L**	**T**	**P**
	3	0	2

Course Outcomes: At the end of this course, students will be able to

1. Understand the chemical processes taking place in water, soil, and air
2. Analyze the research problems related to biochemical processes
3. Devise solutions for changes related to quality of water, wastewater, soil, and air
4. Design the biochemical solutions related to treatment of waste and wastewater
5. Suggest and manage engineering solutions to maintain the environmental quality

Unit 1: Fundamentals of Environmental Chemistry: Covalent and ionic bonding; Chemical equations, concentration and activity; Structure and chemistry of organic molecules; Radioactivity of elements; Chemical equilibrium; Thermodynamics and kinetics of chemical reactions.
Unit 2: Principles of water chemistry: Water quality parameters and their measurement; Acid-base equilibria; Buffer solution; Carbonate system; Solubility of gases in water; Complexation, precipitation, and redox reactions; Inorganic and organic contaminants in water and their speciation.
Unit 3: Atmospheric Chemistry: Composition of the atmosphere; Reactivity of trace substances in the atmosphere; Urban atmosphere—smog and particulate pollution; Chemistry of ozone formation; Chemistry of stratosphere. Soil chemistry: Organic matter, nitrogen, phosphorous, potassium, cation exchange capacity, base saturation, and sodium absorption ratio.
Unit 4: Prokaryotic and eukaryotic microorganisms; Classification of microorganisms; Microbial diversity; Plant-microbe and soil-microbe interactions; Role of microorganisms in wastewater treatment, bioremediation and biogeochemical cycling. Cell chemistry and cell biology: Structure of proteins, nucleic acid (DNA & RNA), lipids and polysaccharides; Bonds in biomolecules; Stereoisomerism in biomolecules; Structure of cell; Structure and function of cytoplasmic membrane, cell wall, outer membrane, glycocalyx, chromosomes, endospores, storage products, mitochondria and chloroplasts. Microbial metabolism: Anabolism and catabolism; Phosphorylation; Glycolysis; TCA cycle; Electron transport chain; Fermentation; Anaerobic respiration; Energy balances; Enzymes and Enzyme kinetics.
Unit 5: Growth and control of microorganisms: Bacterial nutrition and growth; Specific growth rate and doubling time; Monod's model; Types of culture media; Batch and continuous culture; Effects of environmental factors on growth; Control of microbes using physical and chemical methods. Microbiology and health: Pathogens and modes of transmission; Indicator organisms; Quantification of coliforms using MPN and membrane filtration techniques.

References:

1. Environmental Chemistry by Baid & Cann - Freeman & Company
2. Environmental Chemistry by Manahan – CRC Press
3. Chemistry of the Environment by Bailey, Clark, Ferris, Kause, & Strong - Elsevier
4. Microbiology by Pelczar, Can & Kreig – McGraw Hill

ENE511 – Global Warming & Climate Change			
Teaching Scheme	**L**	**T**	**P**
Credit: 4	3	1	0

Course Outcomes: At the end of this course, students will be able to:

1. Assess the status, trends of the changing climate.
2. Analyze and evaluate the underlying causes, mitigation, and adaptation strategies.
3. Evaluate greenhouse gas emissions from different processes at local, regional, and national level.
4. Demonstrate a thorough understanding of the carbon market.
5. Develop/Critique a scientific action plan to combat the environmental issues threatening the planet.

Unit 1: Introduction Description of the climate system, natural and enhanced greenhouse effect, role of trace gases and aerosols, feedbacks in the climate system, Radiative forcing-Definition, concept and processes Forcing –response relationship, Radiative forcing by tropospheric ozone, Radiative forcing of tropospheric aerosols, climate variability on various time-scales.
Unit 2: Sources and Impacts of Climate Change Green House Gases (GHGs) and their Emission Sources, Indicators of global warming, Global Warming Potential (GWP) of GHGs, Impacts of Climate Change Role of Countries and Citizens in Global Warming.
Unit 3: Legislative Framework History of IPCC and UNFCCC, Climate change convention, National and local government responses, Adaptive response and mitigation activity, Scientific and implementation bodies, Kyoto protocol (Different Mechanisms under Kyoto – CDM, JI and ETS), Carbon Market, Paris Agreement, NDCs, Other market based systems for reducing GHG emissions
Unit 4: Emission Inventorization, Adaptation & Mitigation GHG emission calculation – Scope 1, Scope 2, Scope 3 emissions, GHG Protocol, IPCC good practice guidelines, GHG emissions inventorization at the local, regional and national levels., Adaptation & Mitigation – Differentiation, Techniques, Policies.
Unit 5: Other Environmental Issues & Carbon Sequestration Urban heat islands, acid rain, ozone hole. Ecology and various ecosystems; Biodiversity Factors influencing increase in population, energy consumption, and environmental degradation. Conventional and non-conventional techniques; Carbon Sequestration – Basics, different techniques.

References:
1. Climate Change: The physical Science Basis, IPCC (Latest report)
2. Global Warming: The Science of Climate Change - 1st Edition, CRC Press, By: Drake F
3. Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, Wiley. By J. H. Seinfield and S. N. Pandis
4. Climate Change: Impacts, Adaptation and Vulnerability, IPCC (Latest report)
5. Introduction to Environmental Engineering and Science, Pearson, By: Gilbert M Masters

ENE513 – Planning and Design of Environmental Services			
Teaching Scheme	**L**	**T**	**P**
Credit: 4	3	1	0

Course Outcomes: At the end of this course, students will be able to:

1. Apply advanced principles and techniques in environmental engineering planning and design.
2. Analyze concepts, methodologies, and strategies related to environmental engineering planning and design.
3. Evaluate principles, methodologies, and strategies in environmental engineering planning and design.
4. Design innovative and comprehensive environmental engineering plans and solutions by integrating advanced principles, methodologies, and strategies.

Unit 1: Environment and Human-Activity: Resource, Pollution, re-use & management. Planning: Short and long-term planning, Master plan, per capita costs, expansion & extensions.
Unit 2: Land-Use Planning & Management: Impact of land-use on human life, control of hazards in land use, management of land use, assessment of land as waste disposal sites.
Unit 3: Water Plan Optimization & Allocation: Analytical optimization techniques, simulation, growth, theories of settlement, over-crowding, slums, sporadic growth considerations, objectives, and growth with case studies.
Unit 4: Design of conveyance system for source and fugitive, Design of cyclone and cyclone scrubbers, venture-scrubbers, packed towers and fabric filters. Design of control for volatile organic carbon compounds.
Unit 5: Management of private and public managed utilities, management of water supply and sewerage schemes, Environmental objectives and targets, utilities equipment maintenance and preventive maintenance.

References:

1. Arceivala, SJ, Asolekar, SR (2012) Environmental Studies, ISBN-10:1259006050, ISBN-13: 978-1259006050, McGraw Hill Education
2. Christian N Madu (2007) Environmental Planning And Management, Imperial College Press, ISBN-10:1860946712, ISBN-13:978-1860946714
3. Harland Bartholomew, Jack Wood (2014) Land Uses in American Cities, 2nd Reprint Edition, Harward University Press, ISBN-10: 0674866193, ISBN-13: 978-0674866195
4. Birdie GS, Birdie JS (2010) Water Supply and Sanitary Engineering (including Environmental Engineering), Dhanpat Rai Publishing Company (P) Ltd, ISBN-10: 8187433795, ISBN-13: 978-8187433798,
5. N. C. Gautam (2004) Landuse/Landcover and Management Practice in India, BS Publications/BSP Books, ISBN-10: 8178000520
6. Garg SK (2022) Water Supply Engineering Vol-1, 36th Edition, Khanna Publishers, ISBN-13:: 978-81-7409-120-8
7. Syed R Qasim, Edward M Motley, Guang Zhu (2000) Water Works Engineering: Planning, Design And Operation, Prentice Hall, ISBN-10: 0131502115, ISBN-13: 978-0131502116.

ENE515 – Industrial Waste Management			
Teaching Scheme	**L**	**T**	**P**
Credit: 4	3	1	0

Course Outcomes: At the end of this course, students will be able to:

1. Apply advanced techniques in managing industrial wastes effectively, including waste characterization, pollution prevention, and treatment methods.
2. Demonstrate knowledge and skills in industrial waste management, including waste characterization, pollution prevention, and treatment methods, through practical exercises.
3. Analyze industrial waste management challenges for informed decision-making, focusing on treatment methods and pollution prevention.
4. Evaluate industrial waste management practices for efficiency, environmental impact, and sustainability.
5. Design integrated industrial waste management strategies, ensuring regulatory compliance and environmental conservation.

Unit 1: Introduction to Industrial Wastes: Solid, Liquid and Gaseous waste, Management of Industrial Wastewater, Management of Solid Wastes from Industries, and Management of Discharges to the Air, Properties of Water, Polar & Non-polar Solvents, True Solutions, Emulsification, Colloidal Suspensions, and Mixtures made stable by Chelating Agents.
Unit 2: Waste Characterization Study: Wastes Audit, Characteristics of Industrial Wastewater, Characteristics of Discharges to the Air, Characteristics of Solid Waste Streams from Industries.
Unit 3: Wastes from Industries: Textile Wastes; Dairy wastes; Slaughterhouse, Poultry and fish processing waste; Tannery Wastes; Sugar Mill Wastes; Pulp and Paper Mill Waste; Fermentation Industry Waste; Engineering Industry Waste; Petroleum and Petrochemical wastes; Fertilizer and Pesticides Industry waste; Wastes from vegetable, food and allied industries, Rubber Waste.
Unit 4: Pollution Prevention: General Approach, Source Reduction, Waste minimization, strength and volume reduction, segregation, reuse, recycle, material conservation, recovery, Benefits of Pollution Prevention. **Methods for Treating Waste-waters from Industry:** Wastewater Treatment Mechanisms, Waste Equalization, pH Control, Chemical Methods of Wastewater Treatment, Biological Methods of Wastewater Treatment, Physical Methods of Wastewater Treatment.
Unit 5: Treatment and Disposal of Solid Wastes from Industry: Landfilling, Incineration, Composting Industrial Wastes, Solidification and Stabilization of Industrial Solid Wastes. **Methods for Treating Air Discharges from Industry:** Reduction at Source, Containment, and Treatment.

References:

1. Nemerow NL () Industrial Waste Treatment: Contemporary Practice and Vision for the Future, Butterworth-Heinemann,
2. Nemerow NL (1978) Industrial Water Pollution: Origins, Characteristics, and Treatment, Addison-

Wesley, ISBN 10: 0201052466 / ISBN 13: 9780201052466
3. Frank Woodard (2001) Industrial Waste Treatment Handbook, Butterworth–Heinemann, ISBN 0-7506-7317-6
4. WEF Manual of Practice No. FD-3, Industrial Wastewater Management, Treatment, And Disposal, Water Environment Federation, Third Edition, McGraw Hill
5. Zahid Amjad (2010) The Science and Technology of Industrial Water Treatment, IWA Publishing, CRC Press, ISBN 1843393115 ISBN13 9781843393115
6. Wun Jern NG (2006) Industrial Wastewater Treatment, Imperial College Press (ICP), ISBN 1-86094-580-5 ISBN 1-86094-664-X (pbk)
7. Office Of In U S Department Of Energ Bailly Rcg-Hagler () Industrial Waste Gases: Utilization and Minimization, CRC Press, ISBN: 0877627746 ISBN-13: 9780877627746
8. Eckenfelder W. Jr. (1999) Industrial Water Pollution Control, Environmental Engineering and Water Resources Series, 3rd Edition, McGraw-Hill Science/Engineering/Math, ISBN-13: 978-0070393646, ISBN-10: 0070393648
9. Willem Rudolfs (1953) Industrial Wastes: Their Disposal and Treatment, Reinhold Publishing
10. Azad HS (1976) Industrial wastewater management handbook, McGraw-Hill, ISBN 0070026610
11. Patwardhan AD, Industrial Waste Water Treatment, PHI Learning Private Ltd, India, ISBN 9788120333505

SEMESTER 2

ENE502 – Water Resources and Environmental Hydraulics			
Teaching Scheme **Credit: 4**	**L**	**T**	**P**
	3	1	0

Course Outcomes: At the end of this course, students will be able to:

1. Acquire enhanced knowledge of Global water resources, concept of water conservation.
2. Calculate the precipitation, infiltration, evapotranspiration, runoff, hydrographs, unit hydrographs.
3. Understand the different terminologies related with groundwater.
4. Gain Enhanced knowledge of open channel flow & pipe flow and design of channels.

Unit 1: Global Water Resources

Structure, properties and distribution of water; Water quality; Threats to water resources; Water conservation.

Unit 2: Surface Water Resources

Hydrological cycle and water balance - precipitation, infiltration, evapotranspiration, runoff; Flow hydrographs; Unit hydrographs; Stage-discharge relationship; Reservoir capacity; Reservoir and channel routing; Surface run-off models; Surface water management; Rain water harvesting and storage.

Unit 3: Groundwater Resources

Geologic formations as aquifers; Vadose and saturated zones; Confined and unconfined aquifers and their parameters - porosity, permeability, transmissivity and storage coefficient; Darcy's law and applications; Steady state well hydraulics.

Unit 4: Environmental Hydraulics

Concepts of mechanics; Properties of fluids; Pressure measurement; Hydrostatic force on surfaces; Buoyancy and flotation; Laminar and turbulent flow; Flow through pipes; Pipe networks; Boundary layer theory; Forces on immersed bodies; Flow measurement in channels and pipes; Kinematics of flow; Continuity, momentum and energy equations; Channel hydraulics - specific energy, critical flow, hydraulic jump, rapid and gradually varied flow; Design of lined and unlined channels.

References:

1. Engineering Hydrology by K.Subramanya, Tata McGraw Hill
2. Hydrology by V.T. Chow, McGraw Hill
3. Water Resources Systems, by Vedula .S and Mujumdar .P.P, McGraw Hill International Book Company, 2005.
4. Water Resources Engineering, S K Garg
5. Water Resources Engineering, Principles and Practices, Satya Narayana Murty Challa.
6. Hydrology: Principles, Analysis and Design, by Raghunath .H.M, New Age Publications, 2006.
7. David Keith Todd and Larry W. Mays, "Ground water Hydrology" John Wiley and Sons.
8. Water resources management: principles, regulations, and cases By Neil S. Grigg, Tata McGraw Hills.
9. Groundwater Hydrology: Devid Keith Todd
10. Open Channel Flow by V.T. Chow, McGraw Hill
11. Flow in Open Channels by K.Subramanya, Tata McGraw Hill
12. Flow Through Open Channels by K.G.Ranga Raju, Tata McGraw Hill
13. Open Chanel Flow, by Hanif Choudhary M., Prentice Hall of India
14. Open Channel Hydraulics, by Richard French H., McGraw Hill

ENE504 - Solid Waste Management			
Teaching Scheme **Credit: 4**	**L**	**T**	**P**
	3	0	2

Course Outcomes: At the end of this course, students will be able to

1. Understand about the concept and hierarchy of SWM
2. Evaluate and compare different configurations of waste collection and transportation
3. Learn about the design and operation of sanitary landfill
4. Compare different waste treatment methods for effective waste management
5. Design sustainable waste management system for hazardous waste

Unit 1: Introduction

Definition; Sources; Composition & Properties of Municipal solid waste. Handling & Separation of solid waste, Municipal Waste (Management & Handling Rules, 2000), Integrated solid waste management (SWM) System, Hierarchical approach for SWM

Unit 2: Solid Waste Generation, Collection & Disposal

Solid waste generation; Solid Waste Collection; Storage & Processing at source; Transportation; Route Optimization; Waste handling and separation; Methods of Disposal of Municipal Solid Waste

Unit 3: Landfills

Landfills: Site selection, Site preparation, Generation, & Control of Landfill gases; Movement & control of leachate; Landfill design; Landfill closure; Long-term post closure plan, Groundwater monitoring during & after closure

Unit 4: Other Methods of Treatment

Transformation and recycling of waste materials; Composting; Recovery of bioenergy from organic waste. Thermal Conversion Technologies: Incineration, Pyrolysis & Gasification Systems

Unit 5: Hazardous Waste Management

Hazardous waste management: Characteristics, generation, fate of materials in the environment, treatment and disposal. Soil contamination and leaching of contaminants into groundwater. Management of biomedical waste, plastic waste and E-waste: Sources, generation and characteristics; Waste management practices including storage, collection and transfer.

References:

1. Handbook of Solid Waste Management by Kreith & Tchobanoglous - McGraw Hill
2. Design, Construction and Monitoring of Landfills, Amalendu Bagchi, John Willey & Sons, Inc.
3. Final Covers for solid waste landfills and abandoned dumps, R.M. Koerner and David E. Daniel, ASCE press
4. Geo Environmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies, Hari D. Sharma and Krishna R. Reddy

ENE520 - Environmental Monitoring & Assessment			
Teaching Scheme **Credit: 4**	**L**	**T**	**P**
	3	0	2

Course Outcomes: At the end of this course, students will be able to

1. Estimate the status, trends, and changes in environmental quality
2. Collect and analyze the environmental matrices with accuracy to produce reliable data
3. Develop a suitable method for analysis, and its validation with different techniques of analysis
4. Estimate the geographic coverage & extent of environmental quality with known confidence
5. Provide statistical summaries and periodic assessments of environmental quality

Unit 1: Environmental Monitoring

Definition; Advantages of Environmental Monitoring, Methods of assessment of environmental quality; Short term studies/surveys; Rapid assessment; Continuous short and long-term monitoring; Environmental sampling – definition and synthesis of a monitoring/sampling/analysis method; Quality Assurance and quality control (QA/QC)

Unit 2: Sample Collection and Analysis

Methods for sampling/processing/analysis of organic and inorganic constituents in air, water, soil/sediment; Parameters for environmental quality (water, air, soil/sediment); Monitoring of environmental parameters; Chemical Exchange between air-water; Chemical Exchange between sediment-water; Chemical exchange between soil-air; Mass balance

Unit 3: Instrumentation

Spectrophotometry: Principle, working, and applications of Colorimeters, Flame Photometer, UV-visible spectrophotometer, IR spectrophotometer; Gas Chromatography (GC); High Performance Liquid Chromatography (HPLC); X-ray Diffractometer, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM)

Unit 4: Remote Sensing

RS and its applications in Environmental Monitoring: Principles and Basic concepts of Remote sensing; EMR & its interaction with matter; Aerial Photography and image recognition; Sensors & platforms; IRS satellites & their sensors; Application of remote sensing in environmental studies: land use mapping, forest survey, habitat analysis, water management, drought monitoring and flood studies, wetland survey; rainfall estimation, pollution studies, soil conservation, watershed management and vegetation mapping.

Unit 5: Environmental Statistics

Introduction to Statistics and Environmental Application- Probability; Discrete Random Variables and Probability Distributions; Continuous Random Variables and Probability Distributions; Random Samples; Statistical Inferences for means and proportions; Statistical Inferences for means and proportions: Hypothesis Testing; Time Series Analysis; Simple Linear Regression; Multiple Linear Regression.

References:

1. Environmental Monitoring, Assessment, and Management by Morrison, Draggen & Cohrssen – Bloomsberry Academic, USA
2. Environmental Monitoring and Assessment Program (EMAP) by USEPA
3. Environmental Statistics and Data Analysis by Ott – Lewis Publishers
4. Environmental Instrumentation and Analysis Handbook by Down & Lehr – Wiley Publishers
5. Fundamentals of Satellite Remote Sensing: An Environmental Approach by Emilio Chuvieco- CRC Press (Taylor & Francis Group)

ENE522 – Design of Hydraulic Structures			
Teaching Scheme **Credit: 4**	**L**	**T**	**P**
	3	1	0

Course Outcomes: At the end of this course, students will be able to:

1. Knowledge of hydraulic structural elements.
2. Understand the different terminologies related with dam.
3. Analysis the hydraulic structures
4. Design the dam
5. Design the spillways.

Unit 1: Diversion head works:

Layout and functions of components. Causes of failure of weirs on permeable soils, Bligh's theory and Khosla's theory. Irrigation canals- Design of unlined canals through alluvial soils-Kennedy's theory and Lacey's theory.

Unit 2: Minor irrigation structures

Cross drainage works, Canal Regulation works : Falls and Regulators,

Unit 3: Design of Hydraulic Structures

Aqueduct, siphon aqueduct, Canal falls-notch type, well type, Sarda type, and Cross regulator.

Unit 4: Dams

Types, Gravity dam :-forces acting - stability analysis and modes of failure - theoretical and practical profiles- Functions of shafts, galleries, keys and water stops. Arch dams-types, Thin cylinder theory. Earth dams-types, causes of failure and design criteria.

Unit 5: Spillways

Different types of spillways and energy dissipaters, principles and design of spillways,

References:

1. Keshri DN, Analysis and Design of Hydraulic Structures, JBC Press
2. Balasubramanya N, Hydraulic Structures & Irrigation Design Drawing, Sapna Book House
3. Arora, K.R., Irrigation, Water Power and Water Resources Engineering, Standard Publishers Distributors, Delhi 2.
4. Modi, P.N., Introduction To Water Resources And Waterpower Engineering, Standard Publication, Delhi
5. Asawa, G, L Irrigation And Water Resources Engineering, New Age Int. Ltd.
6. R. K. Sharma, "Text Book of Irrigation Engineering and Hydraulic Structures", Oxford and IBH, New Delhi.
7. Sahasrabudhe S.R., Irrigation Engineering & Hydraulic Structures, S.K. Kataria & Sons, 2013
8. Sathyanarayana M. C. Water Resources Engineering-Principles and Practice, New Age International Publishers. 2009
9. Varshney, R.S. Theory & Design of Irrigation Structures - Vol III, Nem Chand & Bros., Roorkee.

ENE524 – Waste Containment & Remediation			
Teaching Scheme **Credit: 4**	**L**	**T**	**P**
	3	1	0

Course Outcomes: At the end of this course, students will be able to

1. Understand the basics behavior of subsurface contaminants in respect of soil and groundwater
2. Analyze the Risk associated and suggest suitable intervention
3. Construct and operate a sanitary landfill.
4. Design a sustainable barrier system to restrict subsurface contamination

Unit 1: Introduction

Soil Formation, Fundamental properties of soil, Hydrogeological settings, Sources of surface and subsurface contamination, Groundwater, Mechanisms of Soil contamination, Physical-chemical and biological interactions in soils, Effect of contamination on geotechnical and environmental properties of soil, Contaminant Transport and Fate

Unit 2: Characterization of Polluted Sites

General Methodology, Preliminary Assessment, Exploratory and Detailed Site investigation, Surveying and Field Testing, Geophysical Methods, Piezometers and monitoring wells, Chemical Analysis, Soil Resistivity Analysis, Risk Assessment of contaminated sites

Unit 3: Landfill Construction and Operation

Landfills, Types of Landfills: Natural attenuation landfill, Containment landfills, Secure Landfills, Bioreactor Landfills, Siting Criteria for landfills, Liner material and design of landfill elements, Operation of Landfill, Monitoring, Landfill Sealing, Post-closure monitoring, Leachate Treatment, Collection of Landfill Gas and its treatment

Unit 4: Waste Containment

Control of soil contamination, Detection, control and remediation of subsurface contamination, Various types of barrier systems, Reclamation of contaminated sites, Restoration, Bioremediation, Economic analysis, Case Studies

References:

1. Geo Environmental Engineering: Principles and Applications, L.N. Reddi and H.I.Inyang, Marcel Dekker, Inc. New York
2. Design, Construction and Monitoring of Landfills, Amalendu Bagchi, John Willey & Sons, Inc.
3. Geo Environmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies, Hari D. Sharma and Krishna R. Reddy
4. Final Covers for solid waste landfills and abandoned dumps, R.M. Koerner and David E. Daniel, ASCE press

ENE530 – Environmental Modelling & Risk Assessment			
Teaching Scheme **Credit: 4**	**L**	**T**	**P**
	3	0	2

Course Outcomes: At the end of this course, students will be able to

1. Understand the basics of air & noise quality research and modeling
2. Develop a skill to analyze the current air & noise quality data
3. Evaluate and predict air & noise pollution impact on society
4. Develop and apply model to resolve air & noise pollution issues
5. Develop concepts of numerical modeling methods and practical applications in environmental engineering and water resource management.

Unit 1: Air Quality Modelling

Introduction to air pollution modeling, Need, types and application of air pollution models, Criteria for model selection, Gaussian plume model, Dispersion models (CALINE), Receptor models (PMF), Emission Inventory, Dispersion of vehicle emission (MOVES), Long range transport models (HYSPLIT), Indoor air quality models, Health exposure models (Air Q+), Traffic noise models (FHWA, CRTN)

Unit 2: Surface Water Modeling

Modeling, Introduction to modeling, different types of models, various numerical methods, finite difference method, solution of system of linear equations, surface water quality modeling.

Unit 3: Groundwater Modeling

Definition, importance, objectives and scope of groundwater modeling. Fundamentals of Groundwater Flow: Darcy's Law and its application, Aquifers: hydraulic conductivity, porosity, permeability, and specific yield. Types of Groundwater Models: Analytical models, Numerical models, Comparison of analytical and numerical modeling approaches. Groundwater Contaminant Transport: Sources and types of groundwater contaminants, Advection, dispersion, and diffusion processes in contaminant transport, Factors influencing contaminant migration and attenuation in aquifers. Validation of groundwater models using field data and monitoring wells. Applications of Groundwater Modeling, Case Studies, Application of MODFLOW / FEFLOW, and/or MT3DMS. Future Trends in Groundwater Modeling.

Unit 4: Human Health Risk Assessment

Basic concepts of environmental risk and definitions, human health risk assessment and its framework – Hazard identification procedures and hazard prioritization.

References:

1. Paolo Zannetti Aero Vironment Inc. Monrovia, California "Air Pollution Modeling: theories, computational methods and available software". Springer Science+ Business Media, LLC, ISBN 978-1-4757-4467-5
2. M.Z. Jacobson, 2005: Fundamentals of Atmospheric Modeling. Cambridge University Press, ISBN 0521548659
3. Boubel R.W., Fox, D.L., Turner D.B.& Stern, A C. "Fundamentals of Air Pollution, Academic Press, New York,1994.
4. Surface Water Quality Modeling by Steven C. Chapra
5. Principles of Surface Water Quality Modeling and Control, E.V. Thomson , Happer and Row Publishers New York, 1987. 3. Schnoor,
6. Environmental Modeling, J. Wiley &Sons., 1996
7. Jacob Bear and Alexander H.-D. Cheng (2010), Modeling Groundwater Flow and Contaminant Transport, *Theory and Applications of Transport in Porous Media Series*, Volume 23, Springer, New York, ISBN 978-

1-4020-6681-8, e-ISBN 978-1-4020-6682-5, DOI 10.1007/978-1-4020-6682-5.

8. Mary P. Anderson, William W. Woessner, Randall J. Hunt () Applied Groundwater Modeling: Simulation of Flow and Advective Transport, Second Edition, Elsevier, ISBN: 978-0-12-058103-0

9. Kammen, D.M. and Hassenzahal, D.M.Should we risk it?: Exploring environmental, health, and technological problem solving. Latest edition,Princeton University Press

ENE532 – Bioremediation			
Teaching Scheme **Credit: 4**	**L**	**T**	**P**
	3	1	0

Course Outcomes: At the end of this course, students will be able to

1. Understand the basics of environmental biotechnology and its applications
2. Analyze the method suitable for treatment/removal of diverse pollutants
3. Develop green and innovative methods suitable for commercial applications
4. Design sustainable environment-friendly solutions using plants
5. Comply with ethical guidelines related to environmental biotechnology

Unit 1: Introduction

Definition and importance of Environmental biotechnology, Biosensors in detection of environmental pollutants: Biomarkers, Biosensors of pollution- BOD, ammonia, methane. Role of microbes in sequestering carbon dioxide, Role of biotechnology in conservation of species: in-situ and ex-situ conservation.

Unit 2: Biodegradation

Recalcitrance of xenobiotics, Biodegradation of Halogenated hydrocarbons, substituted aromatic compounds, Polycyclic aromatic hydrocarbons, Pesticides, Surfactants. Emerging Environmental Biotechnologies: Application of microbial enzymes, Bio-membrane reactors.

Unit 3: Bioremediation of polluted environments

Environmental applications of bioremediation, types of bio-remediation, mechanisms of microbial metal resistance and detoxification, bioremediation of oil spills, limitations of bioremediation, bioremediation and genetic engineering.

Unit 4: Biotechnology and radioactive pollution

Bioleaching; Biosorption and Biotreatment of soils contaminated by radio elements. Phytoremediation: Phytoremediation of xenobiotics and bioaccumulation of metals using plants

Unit 5: Development of biodegradable and eco-friendly products

Fermentation technology; biomass production; Biofuel and Biodiesel-plant derived fuels, bioethanol, biohydrogen; biofertilizers; biopesticides; bio-polymers. Bioethics in Environmental biotechnology: Bioethics issues - Genetically engineered microbes and GM Crops

References:

1. A. Scragg. (2005). Environmental Biotechnology, 2nd Edition, Oxford University Press
2. B. Rittman, P. L. McCarty. (2000) Environmental Biotechnology: Principles and Applications, 2nd Edition, McGraw-Hill.
3. I. S. Thakur. (2006). Environmental Biotechnology: Basic Concepts and Applications. I K International Publications.
4. B.C. Bhattacharya and R. Banerjee (2007). Environmental Biotechnology. Oxford University Press, 2007.
5. J. M. Lynch, A. Wiseman. (1998). Environmental Bio-monitoring: The Biotechnology Ecotoxicology Interface, Cambridge University Press

ENE534 – Remote Sensing & GIS			
Teaching Scheme **Credit: 4**	**L**	**T**	**P**
	3	0	2

Course Outcomes: At the end of this course, students will be able to

1. Apply mapping techniques, remote sensing principles, visual image interpretation, digital image processing methods, GIS fundamentals, and the integration of remote sensing and GIS for spatial analysis in real-world scenarios.
2. Analyze complex geospatial data, mapping techniques, remote sensing principles, digital image processing methods, GIS fundamentals, and their integration for spatial analysis in diverse applications such as urban planning, environmental monitoring, and resource management.
3. Demonstrate advanced skills in data interpretation, problem-solving, and decision-making within the context of geospatial technology applications.
4. Evaluate the effectiveness and applicability of various mapping techniques, remote sensing principles, digital image processing methods, GIS fundamentals, and their integration for spatial analysis in real-world scenarios.

Unit 1: Fundamentals of Mapping and Spatial Referencing Introduction to Mapping, Map Language and Terminology, Spatial Elements in Maps, Classification of Maps, Map Scale and Spatial Referencing, Map Projections and Grid Systems, Map Projections Overview, Commonly Used Map Projections, Grid Systems like Lambert Grid and UTM Grid, Computer and Digital Technologies in Map Production, Role of Computers in Map Production, Digital Databases in GIS, Linkage of GIS to Remote Sensing
Unit 2: Remote Sensing Principles and Technologies Basic Principles of Remote Sensing, Electromagnetic Remote Sensing Process, Physics of Radiant Energy and Spectral Properties, Energy Interactions with Earth's Surface Materials, Microwave Remote Sensing and Radar Systems, Principles of Microwave Remote Sensing, Radar Systems and Interactions with Earth's Surface, Interpretation of SAR Images and Geometrical Characteristics, Remote Sensing Platforms and Sensors, Satellite System Parameters and Sensor Characteristics, Imaging Sensor Systems and Satellite Programs, Latest Trends in Remote Sensing Platforms
Unit 3: Visual Image Interpretation and Digital Image Processing Visual Image Interpretation Techniques, Types of Pictorial Data Products, Image Interpretation Strategy and Elements, Applications of Aerial Photo and Satellite Imagery Interpretation, Digital Image Processing, Basic Characteristics of Digital Images, Preprocessing Techniques like Geometric and Radiometric Corrections, Image Enhancement, Spatial Filtering, and Transformations
Unit 4: GIS Fundamentals and Spatial Data Modeling Fundamentals of GIS, Historical Roots and Overview, GIS Definitions, Terminology, and Architecture, Theoretical Models and Categories of GIS, Spatial Data Modeling and Management, Graphic Representation of Spatial Data, Raster and Vector Data Models, GIS Data Management, Input, and Editing Techniques

Unit 5: Integration of Remote Sensing and GIS for Spatial Analysis

Integration of Remote Sensing and GIS, Synergy between Remote Sensing and GIS, Raster and Vector Data Integration, Urban and Municipal Applications of Remote Sensing and GIS, Role of Satellite Imagery in Urban Analysis, Case Studies and Methodologies in Urban Land Use Mapping, Creation of Information Systems: A Case Study, Objectives, Methodology, and Data Used, Themes like Transportation, Land Use, Water Resources, and Socio-Economic Conditions

References:

1. M. Anji Reddy (2008) Textbook of Remote Sensing and Geographical Information Systems, Third Edition, BS Publications, ISBN:81-7800-135-7
2. George Joseph and C Jeganathan (2018) Fundamentals of Remote Sensing, Third Edition, The Orient Blackswan, ISBN-10: 9386235463, ISBN-13: 978-9386235466
3. A. M. Chandra, S. K. Ghosh (2006) Remote Sensing and Geographical Information System, Reprint Edition, Alpha Science, ISBN-10: 1842652788, ISBN-13: 9781842652787
4. C. P. Lo & Albert K.W. Yeung (2016) Concepts and Techniques of Geographic Information Systems, Second Edition, Pearson Education, ISBN-10: 9789332581883, ISBN-13: 978-9332581883
5. Kang Tsung Chang (2017) Geographic Information System, Fourth Edition, McGraw Hill Education, ISBN-10:0070658986, ISBN-13: 978-0070658981

SEMESTER 3

ENE601 – Environmental Management & Sustainable Development			
Teaching Scheme **Credit: 4**	**L**	**T**	**P**
	3	1	0

Course Outcomes: At the end of this course, students will be able to:

1. Understand the national and global environmental and social challenges.
2. Analyse and quantify the sustainability issues with support from a systems perspective.
3. Evaluate the relevance and appropriateness of environmental management responses in different contexts.
4. Critically analyse the effectiveness of selected key tools and approaches currently used in environmental management.
5. Develop a critical and analytical approach on how to adopt sustainable practices to achieve sustainable goals.

Unit 1: Environmental Management Systems

ISO14000 series; Environmental auditing: Environmental Impact Assessment; Eco-labelling of products, Life cycle assessment

Unit 2: Environmental Law and Policy

Objectives; Polluter pays principle, Precautionary principle; The Water and Air Acts with amendments; The Environment (Protection) Act (EPA) 1986; National Green Tribunal Act, 2010; National Environment Policy; Principles of International Law and International treaties.

Unit 3: Energy and Environment

Energy sources – overview of resources and reserves; Renewable and non-renewable energy sources; Energy-Environment nexus.

Unit 4: Sustainable Development

Definition and concepts of sustainable development; Sustainable development goals; Hurdles to sustainability; Sustainable development strategies, Environment and economics

References:

1. Jennifer A. Elliott. An Introduction to sustainable development. ISBN-13:978-0415590730
2. Asolekar, S. R. and Gopichandran, R. Preventive Environmental Management - An Indian Perspective Foundation Books Pvt. Ltd., New Delhi (the Indian association of Cambridge University Press, UK), 2005.
3. LEAD India (Editor) Rio, Johannesburg and Beyond: India`s Progress in Sustainable Development Orient Longman, Hyderabad, 2002.
4. Welford, R., Corporate Environmental Management, Earthscan Publications Limited, London, 1996.

OEN601 – Green Technology & Sustainability			
Teaching Scheme **Credit: 4**	**L**	**T**	**P**
	3	1	0

Course Outcomes: At the end of this course, students will be able to

1. Understand the basic characteristics of green chemistry and its applications
2. Analyze and devise the treatment of wastewater following principles of green chemistry
3. Develop green and innovative methods suitable for commercial applications
4. Design sustainable environment-friendly solutions for industries
5. Comply with legal and financial standards related to environmental management

Unit 1: Introduction of Green protocol

Conventional Technologies and Environmental degradation, Need for green technologies, Goal and Limitation of Green Technology, Principles of Green Chemistry with their explanations and examples, Atom Economy, Green methods of synthesis- microwave assisted synthesis, solvent free techniques- Reaction on solid support, General synthesis and applications

Unit 2: Clean Development Technologies

Cleaner development mechanisms, role of industry; reuse, reduce and recycle, raw material substitution; wealth from waste; carbon credits, carbon sequestration, eco labelling, waste mining and recycling. Oxidation technology for wastewater treatment- Cavitation, Fenton chemistry, photocatalysis and hybrid processes.

Unit 3: Green Innovation & Sustainability

Criteria for choosing appropriate green energy technologies, life cycle cost; the emerging trends – process/product innovation, technological/environmental leap-frogging; Role of industry, government and institutions; Industrial ecology, Role of industrial complexing in green technology, Green technologies for wastewater and soil treatment

Unit 4: Green Technologies

Eco/green technologies for addressing the problems of Water, Energy, Health, Agriculture and Biodiversity- WEHAB, Eco-restoration, Phytoremediation, Ecological sanitation (ECO-SAN), renewable energy technologies, industrial ecology, agroecology and other appropriate green technologies

Unit 5: Environmental Management and Sustainability

Design for sustainability; Environmental reporting and ISO 14001; Climate change business and ISO 14064; Green financing; Financial initiative by UNEP; Green energy management; Green product management.

References:

1. Sivasubramanian V, Environmental Sustainability Using Green Technologies, CRC Press
2. Arceivala SJ, Green Technologies, Tata McGraw Hill (2014)
3. Sharma SK, Green Chemistry for Environmental Sustainability, CRC Press
4. Alexi Lapkin and David Constable (Eds), Green Chemistry Metrics, Wiley Publications
5. M. Lancaster, Green Chemistry – An introductory Text - RSC

ENE541 - Occupational Health & Safety			
Teaching Scheme **Credit: 2**	**L**	**T**	**P**
	2	0	0

Course Outcomes: At the end of this course, students will be able to:

1. Understand the fundamental aspects of occupational safety & health issues.
2. Analyse the positive and negative consequences of existing industrial health & safety plan.
3. Evaluate and predict the effect of hazard on site engineers & workers.
4. Develop a skill to prepare an effective management plan

Unit 1: Definition; Occupational Health and Environmental Safety Management – Scope & Nature, Principles and Practices; Occupational Safety & Health organization: Policy, Roles & Responsibilities, Planning, Monitoring Review and Audits
Unit 2: Common Occupational diseases, Occupational Health Management Services at the work place; ILO and EPA Standards; Industrial Hygiene; Element of training cycle, Assessment of needs.
Unit 3: Evaluation and control of basic hazards, Physical Hazards, Mechanical Hazards, Electrical Hazards, Chemical Hazard, Ergonomic Hazards; Biological Hazard.
Unit 4: Bureau of Indian standards on safety and health 14489 - 1998 and 15001 – 2000, OSHA, Process Safety Management (PSM) as per OSHA, PSM principles, OHSAS – 18001, EPA Standards, Performance measurements to determine effectiveness of PSM. Importance of Industrial safety, role of safety department, Safety committee and Function.

References:

1. Kohn J and Friend MA, Fundamentals of Occupational Safety and Health, Government Institutes Inc., USA
2. Reese CD, Occupational Health and Safety Management: A Practical Approach (Third Edition)
3. Kelloway, Montgomery, and Francis, Management of Occupational Health and Safety, Nelson College Indigenous Press, 2013

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