ANNA UNIVERSITY, CHENNAI

NON- AUTONOMOUS COLLEGES

AFFILIATED TO ANNA UNIVERSITY

M. TECH., ENVIRONMENTAL SCIENCE AND TECHNOLOGY

REGULATIONS 2025

PROGRAMME OUTCOMES (POs):

PO	Programme Outcomes
PO1	An ability to independently carry out research /investigation and development work to solve practical problems
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PROGRAMME SPECIFIC OUTCOMES(PSOs):

PSO	Programme Specific Outcomes
PSO1	Apply scientific and analytical skills to solve complex environmental problems.
PSO2	Design and evaluate sustainable technologies considering economic, social, and environmental factors.

ANNA UNIVERSITY, CHENNAI

POST GRADUATE CURRICULUM (NON.AUTONOMOUS AFFILIATED INSTITUTIONS)

Programme: M. Tech., Environmental Science and Technology **Regulations:** 2025

Abbreviations:

BS – Basic Science (Mathematics)
ES – Engineering Science (General (**G**), Programme Core (**PC**), Programme Elective (**PE**))
SD – Skill Development
SL – Self Learning

L – Laboratory Course
T – Theory

LIT – Laboratory Integrated Theory
PW – Project Work

TCP – Total Contact Period(s)

Semester I

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	ES25101	Unit Operations and Unit Processes in Environmental Technology	T	3	0	0	3	3	ES (PC)
2.	ES25102	Biological Wastewater Treatment	T	3	0	0	3	3	ES (PC)
3.	ES25103	Air and Noise Pollution Control	T	3	0	0	3	3	ES (PC)
4.	ES25104	Environmental Monitoring and Analysis	T	3	0	0	3	3	ES (PC)
5.	ES25105	Environmental Impact Assessment	T	3	0	0	3	3	ES (PC)
6.	ES25106	Environmental Engineering Lab I	L	0	0	4	4	2	SD
7.	ES25107	Technical Seminar	-	0	0	2	2	1	SD
Total Credits							**21**	**18**	

Semester II

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	ES25201	Separation Processes in Environmental Applications	T	3	0	0	3	3	ES (PC)
2.	ES25202	Solid and Hazardous Waste Management	T	3	0	0	3	3	ES (PC)
3.	ES25203	Environmental Policies and Legislation	T	3	0	0	3	3	ES (PC)
4.	---	Industry Oriented Course I	----	1	0	0	1	1	SD
5.	---	Programme Elective I	T	3	0	0	3	3	ES (PE)
6.	---	Programme Elective II	T	3	0	0	3	3	ES (PE)
7.	ES25204	Environmental Engineering Lab II	L	0	0	4	4	2	SD
8.	ES25205	Separation Processes Lab	L	0	0	4	4	2	SD
9.	---	Self-Learning Course	--	-	-	-	-	1	-
Total Credits							**24**	**21**	

#* Evaluation will be done in third semester for the summer internship.

Semester – III

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
THEORY									
1.	ES25301	Modelling of Environmental Systems	T	3	1	0	4	4	ES (PC)
2.	ES25302	Industrial Pollution Prevention Strategies	T	3	0	0	3	3	ES (PC)
3.	---	Industry Oriented Course II	---	1	0	0	1	1	SD
4.	---	Programme Elective III	T	3	0	0	3	3	ES (PE)
5.	---	Programme Elective IV	T	3	0	0	3	3	ES (PE)
6.	---	Programme Elective V	T	3	0	0	3	3	ES (PE)
7.	ES25303	Project Work I	---	0	0	12	12	6	SD
Total Credits							**29**	**23**	

Semester IV

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	ES25401	Project Work II	---	0	0	24	24	12	SD
			Total Credits				**24**	**12**	

Total Credits for the Programme : 75

Programme Elective Courses (PE)

S. No.	Course Code	Course Title	Periods			Total Contact Periods	Credits
			L	T	P		
1.	CX25C01	Sustainable Management	3	0	0	3	3
2.	CX25C02	Design of Experiments	2	0	2	4	3
3.	CX25C03	Industrial Instrumentation	3	0	0	3	3
4.	ES25001	Ecology and Environment	3	0	0	3	3
5.	ES25002	Environmental Risk Assessment	3	0	0	3	3
6.	ES25003	Risk Analysis and Hazop	3	0	0	3	3
7.	ES25004	Environmental Nanotechnology	3	0	0	3	3
8.	ES25005	Environmental Biotechnology	3	0	0	3	3
9.	ES25006	Waste Management and Energy recovery	3	0	0	3	3
10.	ES25007	Green Chemistry and Engineering	3	0	0	3	3
11.	ES25008	Environmental Sustainability	3	0	0	3	3
12.	ES25009	Principles of Cleaner Production	3	0	0	3	3
13.	ES25010	Advanced Oxidation Processes and Technology	3	0	0	3	3
14.	ES25011	Electrochemical Environmental Technology	3	0	0	3	3
15.	ES25012	Environmental Management	3	0	0	3	3
16.	ES25013	Remote Sensing and GIS Applications in Environmental Management	3	0	0	3	3
17.	ES25014	Soil Remediation Technologies	3	0	0	3	3
18.	ES25015	Environmental Health and Safety in Industries	3	0	0	3	3

SEMESTER I

ES25101	Unit Operations and Unit Processes in Environmental Technology	L	T	P	C
		3	0	0	3

Course Objective:

- To make the students understand the applications of unit operations and processes in environmental technology.
- To enable the students to recognize the basic concept on mixing - coagulation and flocculation.
- To enable the students to apprehend the concept of filtration and its applications.
- To impart knowledge on the concept of chemical precipitation and adsorption.
- To understand applications of aerobic and anaerobic process in the wastewater treatment.

Overview Process Selection: Process Selection, Performance, Reliability, and Resiliency, Technology Assessment and Implementation, Principal type of Reactors, Materials Balance: Concept, Screening Comminutors.

Activity: Compare different reactors for a given treatment scenario and justify selection.

Mixing – Coagulation Mixing, Coagulation and Flocculation, Flow equalization, Theories of Destabilization, Sedimentation, Type of settling, Removal ratio, Clarifier-thickener, Column flotation- air flotation.

Activity: Conduct jar tests for coagulation and flocculation; analyze sedimentation rates.

Filtration: Filtration, Theory of Filtration, classification of filters, Total Head-Loss, Layout of Filters, Backwash, Hydraulic Loading, Darcy equation.

Activity: Demonstration of various filtration equipment.

Chemical Precipitation: Chemical precipitation, phosphate removal, Adsorption, Activated carbon, Isotherms, Disinfection, Factors Influencing, Breakpoint chlorination, De chlorination.

Activity: Perform adsorption experiments using activated carbon.

Aerobic and Anaerobic Process: Kinetics of Biological growth, Suspended and attached growth processes, Aerobic and Anaerobic, Determination of kinetic coefficients.

Activity: Demonstration of Aerobic and Anaerobic process.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (20%), Assignments (30%), Internal Examinations (50%)

References:

1. Reynolds, D., & Richards, A. (1996). *Unit Operations and Processes in Environmental Engineering* (2nd ed.). PWS Publishing Company.
2. Theodore, L., Dupont, R., & Ganesan, K. (2017). *Unit Operations in Environmental Engineering*. Wiley.
3. McCabe, W. L., Smith, J. C., & Harriott, P. (2005). *Unit Operations of Chemical Engineering*. McGraw-Hill Education.
4. Geankoplis, C. J. (2015). *Transport Processes and Separation Process Principles*. Pearson.
5. Metcalf & Eddy, Inc. (2003). *Wastewater Engineering: Treatment and Reuse*. Tata McGraw-Hill Publishing Company.

	Description of CO	**PO**	**PSO1**	**PSO2**
CO1:	Select appropriate wastewater treatment processes and reactor types.	PO1(3), PO2(2)	3	2
CO2:	Apply principles of mixing, coagulation, and sedimentation in water treatment.	PO3(1), PO2(2)	2	3
CO3:	Design filtration systems using hydraulic principles and Darcy's law.	PO1(1), PO3(2)	2	1
CO4:	Analyze biological treatment kinetics for both aerobic and anaerobic processes.	PO3(3)	2	2

ES25102 **Biological Wastewater Treatment**

L	T	P	C
3	0	0	3

Course Objective:

- To make students learn about the methods used for the treatment of wastewater biologically.
- To enable the students to understand the need for aerobic and anaerobic process in sludge management.
- To make the students understand modelling and design aspects of biological techniques available.
- To impart knowledge on operational mechanism of suspended and attached growth reactors.
- To educate the students on the aspects of various biological methods in the real-time effluent treatment.

Fundamental of Biochemical Operations: Objectives of biological wastewater treatment, pollutants characteristics; fundamental, classification and overview of biochemical operations, major types of microorganism and their role, microbial eco system and interactions

Activity: Identify and classify microorganisms from wastewater samples; discuss their roles in treatment.

Aerobic / Anerobic Process and Sludge Management: Aerobic/anoxic and anaerobic process. Aerobic digestion – overview, performance factors, design and operations; Anaerobic processes: background, role and operation process. Sludge Management: Sludge characteristics, production, stabilization; thickening and dewatering; pathogen removal; sludge transformation and disposal methods.

Activity: Demonstrate aerobic and anaerobic digestion processes in the lab.

Suspended Growth Reactors: Principles of suspended Growth Systems, types: Activated Sludge process; types, design and operations; Biological Nutrient Removal: phosphorus and nitrogen removal; aerated lagoons, waste stabilization ponds.

Activity: Visit near by biological waste water treatment unit.

Attached Growth Reactors: Submerged Attached Growth Bioreactors, Membrane biological reactors-Trickling Filters, bio tower, rotating biological contactor, moving bed reactors, fluidized bed reactors – role and process options.

Activity: Build and test a model of a trickling filter or rotating biological contactor.

Industrial Application Case Studies: Future Challenges: fate and effects of Xenobiotic organic chemicals, Industrial application of biological reactor for wastewater treatment

– Case studies: Distillery, Sugar, Pulp and paper, Textile, Dairy, Fertilizer, Pesticides, Pharmaceutical, starch etc.,

Activity: Research and present on biological treatment applications in industries such as textile or pharmaceutical.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (20%), Assignments (30%), Internal Examinations (50%)

References:

1. Grady, C. P. L., Daigger, G. T., & Lim, H. C. (1999). *Biological wastewater treatment*. Marcel Dekker.
2. Hendricks, D. (2011). *Fundamentals of water treatment processes*. CRC Press.
3. Metcalf & Eddy, Inc. (2003). *Wastewater engineering: Treatment and reuse*. Tata McGraw-Hill.
4. Mizrahi, A. (1989). *Biological waste treatment*. Wiley.
5. Patwardhan, A. D. (2008). *Industrial wastewater treatment*. Prentice Hall of India.
6. Spellman, F. R. (2009). *Handbook of water and wastewater treatment plant operations*. CRC Press.

	Description of CO	**PO**	**PSO1**	**PSO2**
CO1:	Explain microbial roles and principles in biological wastewater treatment.	PO1(3), PO2(2)	3	2
CO2:	Distinguish between aerobic and anaerobic processes and sludge handling.	PO3(1), PO2(2)	2	1
CO3:	Design and operate suspended and attached growth reactor systems.	PO1(1), PO3(2)	2	3
CO4:	Analyze real-world applications of biological wastewater treatment technologies.	PO3(3)	2	2

ES25103 **Air and Noise Pollution Control**

L	T	P	C
3	0	0	3

Course Objective:

- To impart knowledge on the air pollution sources, characteristics and effects of air and noise pollution
- To enable the students to learn the methods of controlling the air pollution.
- To impart knowledge on source inventory and control mechanism.
- To enable the students to learn the dispersion mechanisms and models
- To enable the students to learn the health effects and control of noise pollution

Introduction to Air Quality: Types of air pollution, Air pollution effects, Air pollution control laws and regulations An Overview of the Clean Air Act Amendments; Fate and Transport in the Environment; Priority Air Pollutants; Indoor Air Quality. Properties of Air Pollutants; Selected Chemical and Physical Properties of Potential Atmospheric Pollutants; Air pollution measurements Basic Properties and Terminology.

Activity: Measure and analyze local air quality data using online resources or sensors.

Industrial Air Pollution Sources and Prevention: Air Pollution in the Chemical Process industries, Petroleum, Iron and Steel Manufacturing, Lead and Zinc Smelting Industries, Air Pollution from Nickel Ore Processing and Refining; Air Pollution from Copper Smelting industries

Activity: Visit or research an industrial site to identify major air pollution sources and prevention methods.

Ventilation and Indoor Air Quality Control: An Overview of Indoor Air Quality; The Basics of HVAC Systems; IAQ Issues and Impacts on Occupants; Application of Audits to Developing an IAQ Profile; Developing Management Plans; IAQ Problems; Control; Quantification and Measurement, Air Pollution Dispersion-Dispersion Theory Basics-Air Quality Impact of Stationary Sources-Air pollution concentration Models and Resources.

Activity: Conduct an indoor air quality audit in a classroom or office and suggest improvements.

Prevention Versus Control: Pollution Prevention: Principles of Pollution Prevention; Control methods of particulates, VOCs and gaseous pollutants, Environmental Cost Accounting; Total Cost Accounting.

Activity: Evaluate different pollution control technologies for particulates and VOCs through case studies.

Noise Pollution: Noise pollution and its causes, effects measurement and control, Regulations and Laws of Noise pollution, sound level-measuring transient noise-acoustic environment health effects of noise–noise control. Introduction to cosmic pollution.

Activity: Measure ambient noise levels using a sound level meter and analyze noise pollution sources.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (20%), Assignments (30%), Internal Examinations (50%)

References:

1. Anjaneyulu, Y. (2002). Air pollution and control technologies. Allied Publishers.
2. Davis, W. T. (2000). Air pollution engineering manual. Wiley.
3. De Nevers, N. (2011). Air pollution control engineering. McGraw-Hill.
4. Liu, D. H. F., & Lipták, B. G. (2000). Air pollution. Lewis Publishers.
5. Sharma, N., Kumar, A., & Singh, A. P. (2018). Air pollution control. Springer Nature.
6. Stern, A. C. (2006). Air pollution (Vols. I–VIII). Academic Press.
7. Wang, L. K., Pereira, N. C., & Hung, Y.-T. (2005). Advanced air and noise pollution control engineering (Vol. 2).

	Description of CO	**PO**	**PSO1**	**PSO2**
CO1:	Identify sources and effects of air and noise pollution along with applicable regulations.	PO1(3), PO2(2)	3	2
CO2:	Explain industrial air pollution control methods and indoor air quality systems.	PO3(1), PO2(2)	2	1
CO3:	Apply dispersion models to evaluate air pollution impact.	PO1(1), PO3(2)	2	3
CO4:	Analyze noise pollution parameters and implement control techniques.	PO3(3)	3	2

ES25104	Environmental Monitoring and Analysis	L	T	P	C
		3	0	0	3

Course Objective:

- To enable the students to learn the environmental compartments and their interactions.
- To impart knowledge on the various monitoring parameters in water and air.
- To enable the students to detect the composition of various types of solid samples.
- To impart knowledge on environmental laws and regulatory standards.
- To enable the students to learn practically about sampling and measurement of relevant parameters for environmental samples.

Analysis of Environmental Parameters: Introduction, Environmental compartments. Composition of the environmental phases: Water, Air, Earth (soil / sediment). Markers and benchmarks for toxicology and environmental health. Partition constants.

Activity: Test soil, water, and air samples for basic environmental parameters using simple kits or datasets.

Water Quality Assessment and Management: Water & Wastewater Quality. Exposure pathways, health effects. Physical and chemical characteristics of water / waste water. Composition of water. Sampling, monitoring and analysis techniques.

Activity: Collect and analyze water samples for pH, turbidity, and contaminants; discuss health implications.

Air Pollution Analysis and Control: Air Quality. Composition of the atmosphere. Common air pollutants – particulate and vapours. Criteria for ambient air quality. Exposure pathways, health effects. Measurement and characterization of ambient air quality parameters. Particulate matter – PMx definition – aerodynamic diameter; Gas phases samplers, impingers, adsorbents, instrumentation.

Activity: Measure local air quality (PM levels, gases) using portable monitors or data sources; interpret results.

Management of Solid Waste: Composition of solid waste. Characterization techniques. Domestic and industrial solid waste.

Activity: Conduct a waste audit at home or campus to classify and quantify solid waste types.

Environmental Disasters and Regulations: Regulatory standards and agencies (International and national); Environmental disasters – affecting multiple phases. Methods for establishing ambient regulatory standards.

Activity: Research a major environmental disaster and present the regulatory response and outcomes.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (20%), Assignments (30%), Internal Examinations (50%)

References:

1. Manahan, S. E. (2004). Environmental chemistry (8th ed.). CRC Press.
2. Peavy, H. S., Rowe, D. R., & Tchobanoglous, G. (1985). Environmental engineering. McGraw-Hill.
3. Seinfeld, J. H., & Pandis, S. N. (2016). Atmospheric chemistry and physics: From air pollution to climate change. Wiley.
4. Thibodeaux, L. J. (1996). Environmental chemodynamics: Movement of chemicals in air, water, and soil (2nd ed.). Wiley.
5. Thibodeaux, L. J., & Mackay, D. (Eds.). (2010). Handbook of chemical mass transport in the environment. CRC Press.

	Description of CO	**PO**	**PSO1**	**PSO2**
CO1:	Explain environmental compartments and essential parameters for pollution monitoring.	PO1(3), PO2(2)	2	3
CO2:	Assess water quality using various physical, chemical, and biological tests.	PO3(1), PO2(2)	1	3
CO3:	Analyze ambient air quality and recommend control methods for pollutants.	PO1(1), PO3(2)	3	1
CO4:	Characterize solid waste types and evaluate environmental disaster management.	PO3(3)	3	2

ES25105 Environmental Impact Assessment

L	T	P	C
3	0	0	3

OBJECTIVES

- To educate the students about the importance of Environmental Impact Assessment
- To make the students understand the methods followed for the impact assessment.
- To enable the students to learn historical evolution of EIA and to update on latest trends and improvements
- To impart knowledge on the methods for the effective EIA report writing
- To enable the students to learn and apply from existing EIA reports of projects

Components and Types Environmental Impact Assessment (EIA), Environmental Impact Statement (EIS), Environmental Risk Assessment (ERA), Legal and Regulatory aspects in India, Types and limitations of EIA, screening and scoping, Terms of Reference in EIA.

Activity: Review and summarize an existing Environmental Impact Statement (EIS) from a local project.

Impact Prediction and Analysis Components, setting Impact analysis, prediction of impacts, mitigation. Important assessment techniques methods for Prediction and assessment of impacts -Matrices, Networks, Checklists; Impacts – air, water, soil, noise, biological, cultural, social, economic environments; Standards and guidelines for evaluation; cost benefit analysis; analysis of alternatives.

Activity: Use checklists or matrices to predict environmental impacts for a hypothetical project.

Trends and Developments in EIA Public Participation in environmental decision making; trends in EIA practice- strategic environmental assessment; Expert system in EIA; capacity building for quality assurance; use of regulations and AQM; Issues and limitations of EIA.

Activity: Organize a debate or discussion on public participation and limitations of current EIA practices.

Report Writing and Post EIA Document planning - collection and organization of relevant information, use of visual display materials, team writing' reminder checklists. Environmental monitoring – guidelines, policies, planning; Environmental Management Plan; Post-project audit.

Activity: Prepare a brief environmental management plan based on a given case study.

Case Studies Case studies of EIA of developmental projects; Project report on EIA case study.

Activity: Analyze and present a real-world EIA report for a developmental project.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (20%), Assignments (30%), Internal Examinations (50%)

References:

1. Canter, L. W. (1996). *Environmental Impact Assessment*. McGraw-Hill, New York.
2. Petts, J. (2009). *Handbook of Environmental Impact Assessment* (Vols. I & II). Blackwell Science, London.
3. The World Bank Group. (1991). *Environmental Assessment Sourcebook* (Vols. I, II & III). The World Bank, Washington, D.C.
4. Lawrence, D. P. (2003). *Environmental Impact Assessment: Practical Solutions to Recurrent Problems*. Wiley-Interscience, New Jersey.
5. Marriott, B. (1997). *Environmental Impact Assessment: A Practical Guide*. McGraw-Hill.
6. Wathern, P. (1990). *Environmental Impact Assessment: Theory and Practice*. Routledge Publishers.
7. EIA Notification 2006, India

	Description of CO	**PO**	**PSO1**	**PSO2**
CO1:	Explain the key components and legal framework of Environmental Impact Assessment (EIA).	PO1(3), PO2(2)	3	2
CO2:	Apply various techniques like matrices and checklists to predict environmental impacts.	PO3(1), PO2(2)	1	2
CO3:	Evaluate current trends, challenges, and public participation in EIA processes.	PO1(1), PO3(2)	2	2
CO4:	Develop environmental management plans and design effective post-project monitoring.	PO3(3)	3	2

ES25106 Environmental Engineering Lab - I

L	T	P	C
0	0	4	2

OBJECTIVES

- To enable the students to understand the principles of instrumental methods of analysis in environmental application.
- To impart skills in the scientific method of planning, conducting, reviewing, reporting experiments and problem solving in environmental analysis.
- To make students identify and apply correct techniques for the analysis of environmental samples

Exercises

1. Coagulation study
2. Estimation of chlorine dosage and determination of break point for samples.
3. Studies on filtration
4. Settling Characteristics
5. Batch absorption kinetics
6. Column absorption studies
7. Decoloration study using UV-Spectrophotometer
8. Heavy Metal absorption using AAS
9. Organic compound degradation using HPLC
10. Demonstration of GC, FTIR and Lyophilizer

Weightage: Continuous Assessment: 60%, End Semester Examinations: 40%

Assessment Methodology: Project (30%), Assignment (10%), Practical (30%), Internal Examinations (30%)

References:

1. Association of Environmental Engineering and Science Professors Foundation. (2002). AEESP environmental processes laboratory manual. Washington, DC: Author.
2. American Public Health Association, American Water Works Association, & Water Environment Federation. (2012). Standard methods for the examination of water and wastewater. Washington, DC: American Public Health Association.
3. Lee, C. C., & Lin, S. (2007). Handbook of environmental engineering calculations. New York, NY: McGraw-Hill.

4. Metcalf & Eddy, Inc. (2003). Wastewater engineering: Treatment and reuse. New York, NY: McGraw-Hill.
5. Sawyer, C. N., McCarty, P. L., & Parkin, G. F. (2003). Chemistry for environmental engineering. New Delhi, India: Tata McGraw-Hill.

	Description of CO	**PO**	**PSO1**	**PSO2**
CO1:	Conduct key water treatment experiments including coagulation, filtration, and settling.	PO1(3), PO2(2)	3	2
CO2:	Analyze contaminant removal using absorption kinetics and advanced analytical instruments.	PO3(1), PO2(2)	2	3
CO3:	Demonstrate practical knowledge of instrumental techniques like UV-Vis, AAS, HPLC, GC, and FTIR.	PO1(1), PO3(2)	3	1

ES25201 Separation Processes in environmental Applications L T PC
2 0 2 3

OBJECTIVES

- To enable students to learn the fundamentals of separation processes.
- To enable students to understand the basic concept of phase equilibria and gain knowledge on distillation, trouble shooting in distillation tower
- To impart knowledge on extraction in applications in the environmental field.
- To inculcate knowledge on Ion exchange in applications in the environmental field
- To enable students to understand applications of membrane process in the environmental field

Distillation & Extraction
Batch and Continuous distillation, Troubleshooting in Distillation tower; Extraction in Environmental applications, Leaching.

Absorption and Adsorption
Absorption and stripping, packed columns; Adsorption principles, Sorbent selection, regeneration, Process design factors, equipment's for adsorption.

Drying & Filtration
Mechanism of drying, types and application of drying; Concept behind filtration, Types of filtration and its environmental application

Ion-Exchange
Ion-exchange - Environmental applications, Ion-exchange mechanisms, Ion exchange media, equipment's used for ion exchange

Membrane Processes
Membrane processes, membrane materials, types of membranes, membrane modules, Environmental applications.

Course Outcomes:

CO1 Recall the equilibrium relationships, the fundamental concepts of distillation, extraction & leaching and perform design calculations
CO2 Review the concept of gas–liquid and fluid – solid operations for environmental applications.
CO3 Discuss the principles, types and applications of drying and filtration
CO4 Explain the Ionexchange mechanism and design the system for environmental application
CO5 Recognize the basic principle, different types of embrane, membrane modules and various membrane process and its mechanisms.

Reference Books

1. Noble,R.D andTerryP.A.,PrinciplesofChemical SeparationswithEnvironmental Applications, CambridgeUniversityPress,2004.
2. SeaderJD and HenleyEJ, SeparationProcessesPrinciples,3rdEdition,JohnWiley&Sons, 2011.
3. Reynold D and Richards A, " Unit Operations and Processes in Environmental Engineering" 2nd Edition, PWS Publication, 1996
4. Treybal R E, Mass Transfer Operations, McGraw Hill 1981.
5. Geankoplis, J,C, "Transport Processes and Separation Process Principles" 4th edition, Pearson publication , 2015

Course Articulate Matrix:

Course Outcomes	PROGRAM OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	3	2	2	1
CO2	3	2	3	3	2	1
CO3	3	2	3	3	2	1
CO4	2	1	3	3	2	2
CO5	3	1	3	3	2	1
CO6	2	2	1	2	1	1
CO7	2	2	1	2	1	1
CO8	2	2	1	2	1	1
AVERAGE CO	**2.5**	**1.7**	**2.2**	**2.5**	**1.6**	**1.1**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

ES25202 **Solid and Hazardous Waste Management** L T P C
3 0 0 3

OBJECTIVES

- To impart knowledge about valuing the environment and make it cleaner and greener by safe disposal of solid wastes
- To understand the various unit operations involved in transformation of solid wastes
- To inculcate knowledge about hazardous wastes and its characteristics
- To enable the students to know about hazardous waste landfill
- To enable the students to learn about the different methods of sampling and characterization techniques of solid and liquid wastes

Introduction to Solid Waste Management
Solid waste - waste generation in a technological society, sources and types of solid waste; legislations on management and handling of municipal solid wastes; special waste-hazardous wastes, biomedical wastes, batteries waste, E-waste and plastics; monitoring responsibilities-waste minimization at source,7 types of R in SWM

Unit Operations Involved In Energy Recovery From Waste
Collection of Solid Waste- type of waste collection systems, analysis of collection system, alternative techniques for collection system. Storage of municipal solid waste at source; Separation and Processing and Transformation of Solid Waste- unit operations used for separation and processing; Materials Recovery facilities; Waste transformation - combustion and anaerobic composting, anaerobic methods for materials recovery and treatment. Energy recovery - Incinerators. Transfer and Transport- need for transfer operation, transport means and methods, transfer station types and design requirements. Landfills-Site selection, design and operation, drainage

Handling And Storage of Hazardous Waste
Definition and identification of hazardous wastes - sources and characteristics; hazardous wastes in Municipal Waste; Hazardous waste handling- transportation and storage rules & regulations; minimization of Hazardous Waste; compatibility, handling and storage of hazardous waste; collection and Transport; hazardous waste management practice in India

Disposal of Hazardous Wastes
Hazardous waste treatment technologies - Design and operation of facilities for physical, chemical and thermal treatment of hazardous waste. Waste transformation- Solidification, chemical fixation and encapsulation, incineration. Hazardous waste landfills- Site selection, design and operation; remediation of hazardous waste disposal sites.

Sampling of Wastes
Sampling and characterization of Solid Wastes; toxicity analysis- TCLP tests; leachate studies-composition of landfill leachate; leachate management and treatment; leachate drainage systems

Course Outcomes

CO1 Explain the legislation pertaining to solid waste management

CO2 Describe the solid waste remedial measures and their importance.

CO3 Asses the energy production using solid wastes

CO4 Recognize and recall the toxicity of materials over the environment
CO5 illustrate the sampling of solid wastes and its analysis

Reference Books

1. Techobanoglous G, Integrated Solid Waste Management, McGraw- Hill Publication, 1993.
2. Wentz C A, Hazardous Waste Management, McGraw-Hill Publication, 1995.
3. Michael D. LaGrega, Philip L Buckingham, Jeffrey C. E vans and Environmental Resources Management, Hazardous Waste Management, Mc-Graw Hill International edition, New York, 2001
4. CPHEEO, “Manual on Municipal Solid waste management, Central Public Health and Environmental Engineering Organization, Government of India, New Delhi, 2000.
5. Vesilind P.A., Worrell W and Reinhart, Solid waste Engineering, Thomson Learning Inc., Singapore, 2002

COURSE ARTICULATE MATRIX:

Course Outcomes	PROGRAM OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	3	3	1	2	2
CO2	-	-	2	2	2	3
CO3	3	-	3	-	2	2
CO4	2	-	-	3	2	2
CO5	3	-	3	-	2	2
AVERAGE CO	**2.5**	**3**	**2.75**	**2**	**2**	**2.2**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

ES25203	Environmental Policies and Legislation	L T P C 3 0 0 3

OBJECTIVES

- To enable the students to understand the current status of the emerging environmental issues
- To make the students to learn the developments in national & international environmental law and the fundamental principles that have emerged.
- To enable the students to comprehend the statutory and regulatory mechanisms pertaining to environment in India.
- To assist the students to understanding judicial response to environmental issues in India.
- To enable the students to learn appropriate environmental management plans and know the importance of EIA

Introduction

Introduction of international environmental law; Principles of environmental law-Polluter pays principle, precautionary principle, sustainable development; Indian Constitution and Environmental Protection – National Environmental policies –– Concept of absolute liability – multilateral environmental agreements and Protocols – Montreal Protocol, Kyoto agreement; United Nations Framework Convention on Climate Change- Paris Agreement; Environmental Protection Act; Institutional framework (SPCB/CPCB/MoEF).

Water (P&Cp) Act, 1974

Law relating to Water pollution; Power & functions of regulatory agencies - responsibilities of Occupier; Provision relating to prevention and control Scheme- Consent to establish, Consent to operate – Conditions of the consents; Outlet – Legal sampling procedures, State Water Laboratory – Appellate Authority – Penalties for violation of consent conditions etc.; Provisions for closure/directions in apprehended pollution situation; Coastal regulation laws in India.

Air (P&CP) Act, 1981

Law relating to Air Pollution; Power & functions of regulatory agencies - responsibilities of Occupier; Provision relating to prevention and control Scheme- Consent to establish, Consent to operate – Conditions of the consents; Outlet – Legal sampling procedures, State Air Laboratory – Appellate Authority – Penalties for violation of consent conditions etc.; Provisions for closure/directions in apprehended pollution situation; Ozone depletion- Climate change law.

Environment (Protection) ACT 1986

Genesis of the Act – delegation of powers, Role of Central Government, Role of NGO in environmental protection.EIA Notification – Environment Impact Assessment-Introduction, comprehensive of EIA, methodology, framework of EIA, considerations, application, purpose of EIA; EIA for major industries – like steel plants, power plants, and chemical industries.

Legal Framework And Strategies For Waste Management

Law relating to Waste management- Strategies for Waste Management- Law on Management of Hazardous Waste and Biomedical Wastes in India; Law Relating to Management of Solid Waste-Plastic waste- E-Waste - Construction and Demolition Waste in India.

COURSE OUTCOMES

CO1 Understand the emerging environmental issues.
CO2 Explain the laws, analytical techniques involved in water pollution control
CO3 Discuss the laws, analytical techniques involved in air pollution control
CO4 Review appropriate environmental management plans to prevent or mitigate various adverse impacts of the industrial activities on environment.
CO5 Analyse the importance of EIA and steps involved in conducting a systematic Environmental Impact Assessment.

REFERENCES:

1. Environmental Law in India | P Leela Krishnan | Environment | EBC | 2022
2. Environmental Law, Policy, and Economics, Reclaiming the Environmental Agenda By Nicholas A. Ashford and Charles C. Caldart. The MIT press, 2017.
3. CPCB, "Pollution Control acts, Rules and Notifications issued there under "Pollution Control Series – PCLS/02/2021-2022, Central Pollution Control Board, Delhi, 1997. Website: http://www.cpcb.nic.in
4. Shyam Divan and Armin Roseneranz "Environmental law and policy in India "Oxford University Press, New Delhi, 2001.
5. GregerI.Megregor, "Environmental law and enforcement", Lewis Publishers, London. 1994.

COURSE ARTICULATION MATRIX:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	-	3	3	3
CO2	3	1	-	3	3	3
CO3	-	1	-	3	3	3
CO4	1	1	-	3	3	3
CO5	-	1	-	3	3	3
Average CO	**1**	**1**	**-**	**3**	**3**	**3**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

ES25204 **Environmental Engineering Lab II** L T P C
0 0 4 2

Objectives

- To enable the students to understand the principles of instrumental methods of analysis in environmental application.
- To impart skills in the scientific method of planning, conducting, reviewing, reporting experiments and problem solving in environmental analysis.
- To make students identify and apply correct techniques for the analysis of environmental samples

1. Coagulation study
2. Estimation of chlorine dosage and determination of break point for samples.
3. Studies on filtration
4. Settling Characteristics
5. Batch absorption kinetics
6. Column absorption studies
7. Decoloration study using UV-Spectrophotometer
8. Heavy Metal absorption using AAS
9. Organic compound degradation using HPLC
10. Demonstration of GC, FTIR and Lyophilizer

TOTAL: 60 PERIODS

Course Outcomes:

CO1 Demonstrate proficiency in effective coagulation and filtration techniques for wastewater treatment.
CO2 Apply precise chlorine dosage and break point determination in water treatment strategies.
CO3 Assess absorption kinetics and conduct UV-based decolouration studies for water quality improvement.
CO4 Demonstrate proficiency in using advanced instruments for environmental analysis.

Reference Books:

1. AEESP Environmental Processes Laboratory Manual, Association of Environmental Engineering and Science Professors Foundation, Washington, 6th Ed. 2002.
2. APHA, AWWA, WEF. Standard Methods for Examination of water and wastewater. 22nd Ed. Washington: American Public Health Association; 2012.
3. Lee, C.C. and Shundar Lin. Handbook of Environmental Engineering Calculations, 2 nd Ed. Mc Graw Hill, New York, 2007
4. Metcalf & Eddy, Inc. Wastewater Engineering: Treatment and Reuse. 4 th Edition. McGrawHill, New York, NY. 2003.
5. Sawyer, C.N., McCarty, P.L., and Parkin, G.F. Chemistry for Environmental Engineering 5 th Edition. Tata McGraw-Hill Publishing Company Limited. 2003.

Course Articulate Matrix:

Course Outcomes	**PROGRAM OUTCOMES**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	3	3	2	3
CO2	2	3	3	3	3	3
CO3	2	2	3	3	3	3
CO4	3	3	3	3	3	3
AVERAGE CO	**2.25**	**2.5**	**3**	**3**	**2.75**	**3**

1, 2 and 3are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

ES25205 SEPARATION PROCESSES LABORATORY L T P C
0 0 4 2

OBJECTIVES:

To develop sound practical knowledge for students on various Separation processes which have their Environmental applications

LIST OF EXPERIMENTS

1. Separation of binary miscible solution using simple batch distillation
2. Separation of binary miscible solution using Continuous distillation
3. Liquid-liquid Extraction
4. Cross current leaching studies
5. Gas – Liquid Absorption
6. Adsorption studies
7. Separation using Ion-Exchange column
8. Determination of permeate flux, permeate rejection and permeate characteristics in membrane.
9. Vacuum Filtration
10. Determination of Moisture content and drying rate in a Dryer.
11. Sieve analysis

TOTAL: 60 PERIODS

COURSE OUTCOMES

The students will be able to

	Description of CO	PO	PSO1	PSO2
CO1	Perform distillation and Determine Distillation parameters	PO2(1), PO3(1)	1	2
CO2	Evaluate the performance and determine Extraction parameters	PO2(2)	2	1
CO3	Estimate the Adsorption/Absorption parameters	PO3(2)	2	2
CO4	Analyse and perform separation using Ion-Exchange operation	PO3(2)	1	1
CO5	Analyse and determine various Filtration parameters	PO1(2)	2	1

ES25301 Modeling of Environmental Systems L T P C
3 1 0 4

OBJECTIVES

- To enable the students to understand the basics of environmental modelling and its methodology
- To facilitate the students to learn about different types of environmental systems and their characteristics
- To enable the students to impart knowledge on complex features and dynamics of environmental systems
- To enable the students to learn about various software tools used for environmental modelling and decision making
- To expedite the students to develop models and make futuristic predictions of various environmental systems

Modelling of Environmental Systems
Principles of Environmental modeling, Complexities in modelling environmental systems; Different types of environmental systems; model building and types, Classification of mathematical models, Model Calibration, Validation, Verification and Sensitivity Analysis, uncertainty sources; Methods of solution

Modelling Approaches
Mechanistic modelling, Data driven approaches- Neural Network, Fuzzy System Modeling for environmental systems; Future Directions in Environmental Modeling

Hydrological System
Basic mechanisms of river self-purification, Streeter-Phelps and Dobins models; More complex chemical and ecological models; Pollutant and nutrient dynamics, Dissolved Oxygen dynamics.
Case study: Predict Surface Runoff Water Quantity and Quality in Agricultural Fields using data driven models

Microbial System
Fundamentals of microbial dynamics; Pollutant/Microorganisms interactions, Population Dynamics: Birth and death processes microbial dynamics calculations; Process schemes: CSTR, plug-flow, SBR; Anaerobic digestion, process dynamics
Case study: Population dynamics Modelling and operational control of wastewater treatment processes

Eco System Modeling
Single species growth, Prey-predator models: Lotka - Volterra, Rosenzweig- MacArthur, Kolmogorov models; Multi-species models, Primary production, primary and secondary consumers; Structural analysis and stability of complex ecosystems.
Case study: Modelling using mechanistic and data driven approaches

COURSE OUTCOMES:

CO1 Recognize the fundamentals of mathematical modeling
CO2 Analyze data driven environmental models
CO3 Discuss about ecology and multidimensional modeling
CO4 Apply knowledge in hydrology and behavioral systems
CO5 Evaluate themselves to model interactive systems

References:

1. Schnoor, J.L., Environmental Modeling Fate and Transport of Pollutants in Water, Air and Soil, John Wiley & Sons Inc., New York, 1996.
2. Nirmalkhandan N. (2001) Modeling Tools for Environmental Engineers and Scientists, CRC Press, Boca Raton, Florida.
3. Ramaswami A., Milford J.B. and Small M.J. (2005) Integrated Environmental Modelling, John Wiley and Sons, Inc., New Jersey.
4. Deaton, M.L and Winebrake, J.J., Dynamic Modeling of Environmental Systems, Verlag, 2000.
5. Orhon, D and Artan, N., Modeling of Activated Sludge Systems, Technomic Publ.Co., 1994.
6. Chapra, S.C. Surface Water-Quality Modeling, McGraw-Hill, 2008.

COURSE ARTICULATE MATRIX:

Course Outcomes	PROGRAM OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	-	3	1	3
CO2	3	3	1	3	1	3
CO3	3	-	2	3	1	1
CO4	3	2	3	3	-	1
CO5	1	1	2	3	2	2
AVERAGE CO	**2.6**	**2**	**2**	**3**	**1.6**	**2**

1, 2 and 3are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

ES25302 **Industrial Pollution Prevention Strategies** L T P C
3 0 0 3

OBJECTIVES

- To enable students to understand the basics of industrial pollution
- To expedite student to understand and apply appropriate control and preventive measures for different types of pollution.
- To enable the students to develop the ability of framing pollution control strategies
- To provide knowledge on sources and characteristics of industrial pollution, techniques and approaches for control and minimization of pollution.
- To impart the knowledge and understanding of causes and effects of different pollution and their controlling mechanisms

Industrial Pollution

Industrial pollution- Definition- source- types of pollutant generated in an industry- solid, liquid, gaseous & noise - their effects on the environment; Environmental regulatory legislations and standards; Importance of industrial pollution abatement; Concept of sustainable development; Greenhouse gases- Global warming and Ozone depletion.

Pollution Prevention

Principles and techniques for industrial pollution prevention and waste minimization; Nature and characteristics of industrial wastes; Prevention versus control of industrial pollution; Source reduction tools and techniques- raw material substitution, toxic use reduction and elimination, process modification and procedural changes; Recycling and reuse; Opportunities and barriers to cleaner technologies; Pollution prevention economics; Waste audits, emission inventories and waste management hierarchy for process industries.

Pollution Control Strategies

Pollution control strategies - cradle to grave concept, life cycle analysis, clean technologies; concept of zero discharge effluent. Pollution prevention frame work – Government perspective-Incentives-Barriers-Regulations-Recycling and Reuse of Wastes, Resource recovery; Case studies - Managing Pollution Control in Chemical Process Industries.

Air Pollution Control Acts & Rules

Air (Prevention & Control of Pollution) Act, Air pollution-sources and types of Pollutants-Adverse effects - Air pollution control devices; Air pollution emission standards; Emerging technologies and strategies to mitigate air pollution.

Water Pollution Control Acts & Rules

Water (Prevention & Control of Pollution) Act, 1974- Introduction to various aspects of water pollution and water quality standard; Power & functions of regulatory agencies - responsibilities of Occupier Provision relating to prevention and control Scheme of Consent to establish, Consent to operate – Conditions of the consents – Outlet – Legal; sampling procedure

Course Outcomes:

Upon completion of the course, students will acquire knowledge on

CO1 Understand the basics of industrial pollution.
CO2 Identify and apply appropriate control and preventive measures for different types of pollution
CO3 Develop ability to build pollution control strategies.
CO4 Design the control techniques for minimizing emissions
CO5 Appreciate the importance of Water pollution control Acts and rules

Reference Books:

1. Pollution Control in Process Industries by S.P. Mahajan – 2004
2. Bishop P.E. Pollution Prevention: Fundamentals and Practice, McGraw Hill.
3. Industrial Pollution Prevention Handbook, Harry Freeman
4. Eckenfelder, W. W., Industrial Water Pollution Control, McGraw-Hill
5. Shyam Divan and Armin Roseneranz "Environmental law and policy in India "Oxford University Press, New Delhi, 2001

Course articulation matrix:

Course Outcomes	PROGRAM OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	-	1	2	-	1
CO2	2	-	1	2	-	3
CO3	2	3	1	-	-	1
CO4	1	3	1	2	-	1
CO5	-	-	1	-	-	1
AVERAGE CO	**1**	**1.2**	**1**	**1.2**	**-**	**1**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

CX25C01 **Sustainable Management** L T P C
3 0 0 3

Objectives

- To enable the students to learn the fundamentals of sustainability in the context of engineering.
- To enable the students to analyze the environmental impact of chemical processes and identify opportunities for improvement.
- To impart knowledge on sustainable process design and optimization techniques.
- To enable students to evaluate energy efficiency and resource conservation strategies in industries/ plants.
- To enable students to develop skills for implementing sustainable practices in engineering projects and operations.

Introduction to Sustainable Management

Overview of sustainability principles and their relevance to chemical/petroleum/environmental engineering, Environmental challenges in the chemical industry, Introduction to sustainable development goals and their application in chemical engineering, Role of engineers in promoting sustainability, Introduction to life cycle assessment (LCA) and environmental impact analysis

Sustainable Process Design and Optimization

Principles and strategies for sustainable process design, Analysis and optimization of chemical processes for sustainability, Integration of green chemistry principles in process design, Case studies on sustainable process design in chemical engineering, Tools and software for sustainable process design and optimization

Energy Efficiency and Conservation

Energy consumption and environmental impact of chemical processes, Strategies for improving energy efficiency in chemical plants, Energy conservation techniques in heat transfer, separation processes, and reactions, Integration of renewable energy sources in chemical processes, Case studies on energy-efficient operations in chemical engineering.

Waste Minimization and Resource Recovery

Waste generation in chemical processes and its impact on the environment, Techniques for waste minimization and treatment, Resource recovery from waste streams, Recycling and circular economy principles in chemical engineering, Case studies on waste reduction and resource recovery in chemical processes.

Sustainable Supply Chain Management in Industry

Sustainability considerations in the chemical supply chain, Responsible sourcing of raw materials, Green packaging and logistics practices, Supplier assessment and management for sustainability, Certification systems and standards for sustainable supply chains.

COURSE OUTCOMES

CO1 Identify and discuss the key principles and concepts of sustainability in the context of engineering.

CO2 Analyze and evaluate the environmental impact of chemical processes and propose sustainable solutions.

CO3 Design and optimize chemical processes considering sustainability factors and green chemistry principles.

CO4 Assess and implement energy-efficient strategies and resource conservation techniques in chemical plants.

CO5 Apply sustainable supply chain management principles to ensure responsible sourcing and minimize environmental impact.

References:

1. Beder, Sharon., “Environmental principles and policies: an interdisciplinary introduction”, Routledge, 2013.
2. Elkington, John, and Ian H. Rowlands. "Cannibals with forks: The triple bottom line of 21st century business." Alternatives Journal 25, no. 4,42, 1999.
3. Fiksel, Joseph. Design for environment: a guide to sustainable product development. McGraw-Hill Education, 2009.
4. Johansson, Allan. Clean technology. CRC Press, 1992.
5. Kane, Gareth. The green executive: corporate leadership in a low carbon economy. Routledge, 2012.
6. Kirkwood, Ralph, and Anite Longley, eds. Clean technology and the environment. Springer Science & Business Media, 1994.
7. Mulder, Karel, ed. Sustainable development for engineers: A handbook and resource guide. Routledge, 2017.
8. Marinova, Dora, David Annandale, and John Phillimore, eds. The international handbook on environmental technology management. Edward Elgar Publishing, 2008.
9. Von Weizsäcker, Ernst Ulrich, Amory B. Lovins, and L. Hunter Lovins. Factor four: doubling wealth—halving resource use: a new report to the club of Rome. Springer International Publishing, 2014
10. Willums, Jan-Olaf. The sustainable business challenge: a briefing for tomorrow's business leaders. Routledge, 1998.
11. Harmsen, Jan, and Joseph B. Powell. Sustainable development in the process industries. Hoboken, NJ: John Wiley & Sons, 2010.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Identify and discuss the key principles and concepts of sustainability in the context of engineering	3	3	3	1	1	1
CO2	Analyze and evaluate the environmental impact of chemical processes and propose sustainable solutions	1	2	2	3	3	2
CO3	Design and optimize chemical processes considering sustainability factors and green chemistry principles	2	3	3	3	3	2
CO4	Assess and implement energy-efficient strategies and resource conservation techniques in chemical plants	2	2	1	3	1	1
CO5	Apply sustainable supply chain management principles to ensure responsible sourcing and minimize environmental impact	1	2	2	2	3	2
Average CO		1.80	2.40	2.20	2.40	2.20	1.60

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

CX25C02 **Design of Experiments** L T P C
2 0 2 3

OBJECTIVES

- To impart knowledge sampling and sampling distribution and to apply hypothesis testing with different confidence intervals.
- To enable the students, develop skills in linear regression, both univariate and multivariate, and utilize least squares methods to estimate and interpret regression models.
- To enable the students to interpret experimental results using ANOVA, report data, and construct confidence intervals.
- To enable the students to perform ANOVA and regression analysis.
- To enable the students to explore variable selection, fractional factorial design, and robustness in experimental design.

Foundations of Probability and Statistics for Engineers
Introduction to probability and statistics, including concepts and principles. Statistical inference fundamentals, such as estimation and hypothesis testing. Confidence intervals, providing a range of plausible values for population parameters. Hypothesis tests to make decisions based on experimental data.

Principles of Experimental Design
Statistical principles in experimental design, including the control of sources of variation. Blocking and complete randomization techniques. Factorial design to study the effects of multiple factors on the response variable. Analysis of individual factor effects and interaction effects. Introduction to response surface methodologies for optimizing response variables within a design space.

Regression Modeling and Analysis
Linear regression techniques, both univariate and multivariate, to model relationships between variables. Least Squares estimation, including its basic principles and variants. Nonlinear regression methods to model non-linear relationships. Techniques for model assessment, interpretation, and evaluation of regression models

Analysis of Variance and Experimental Inference
Introduction to ANOVA, a statistical technique for comparing means among multiple groups or treatments. Interpretation of results from experiments using ANOVA. Effective reporting of experimental data. Construction of confidence intervals to estimate population means and differences.

Advanced Topics in Statistics and Experimental Design
Exploration of additional topics in statistics and experimental design. Variable selection techniques to identify significant factors in regression models. Fractional factorial design for efficient exploration of factor combinations. Robustness in experimental design and analysis, focusing on the stability and reliability of statistical methods in the presence of deviations from assumptions.

List of tasks to be performed by students: Software Minitab

1) **Exploratory Data Analysis:** Import a dataset into Minitab and perform exploratory data analysis. Calculate descriptive statistics, such as mean, median, and standard deviation. Create graphical representations of the data, including histograms, box plots, and scatter plots

2) **Probability Distribution Analysis:** Generate random numbers from different probability distributions in Minitab, such as normal, exponential, or binomial. Fit probability distributions to data and assess goodness-of-fit using Minitab's distribution fitting tools.

3) **Hypothesis Testing and Confidence Intervals:** Formulate hypotheses and perform hypothesis tests using Minitab for various scenarios. Conduct t-tests, chi-square tests, or ANOVA tests to compare population means or proportions.

4) **Experimental Design and Analysis:** Design and execute experiments using Minitab's design of experiments (DOE) tools. Analyze the results of designed experiments, including factorial designs, using Minitab's DOE analysis features. Assess the significance of factor effects and interaction effects.

5) **Regression Modeling and Analysis:** Perform linear regression analysis in Minitab to model relationships between variables. Interpret the coefficients and significance of predictors in regression models. Assess the goodness-of-fit and validity of regression models using diagnostic plots and statistical tests in Minitab.

Course Outcomes:

CO1: Recognize and recall foundational probability and statistics concepts and apply them to solve engineering problems.
CO2: Apply statistical inference techniques to draw conclusions from experimental data.
CO3: Analyze variance (ANOVA) technique and apply it to experimental design and interpretation of results.
CO4: Illustrate skills in linear regression modeling and interpret regression models for engineering applications.
CO5: Apply statistical principles to experimental design and assess model adequacy for regression models.

Practical

CO1: Recall and apply foundational statistical concepts in practical data analysis using software tools like Minitab.
CO2: Demonstrate proficiency in conducting hypothesis tests, constructing confidence intervals, and analyzing experimental data using software.
CO3: Analyze regression models, interpret their coefficients, and evaluate model adequacy through diagnostic plots and statistical tests using software.

References:

1. R.L. Mason, R.F. Gunst and J. L. Hess (2005). Statistical Design and Analysis of Experiments – with applications to engineering and science, 2nd edition, John Wiley & Sons
2. Design of Experiments in Chemical Engineering: A Practical Guide by Z. R. Lazic, John Wiley
3. R.A. Johnson, I. Miller and J. Freund (2007). Probability and Statistics for Engineers, 7 th edition, Prentice Hall Inc
4. D.C. Montgomery and G.C. Runger (2007). Applied Statistics and Probability for Engineers, 4th edition, John Wiley & Sons Inc.
5. Box, George EP, J. Stuart Hunter, and William G. Hunter. "Statistics for experimenters." In Wiley series in probability and statistics. Hoboken, NJ: Wiley, 2005.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes					
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	Recognize and recall the fundamental concepts of probability and statistics and apply them to engineering problems.	3	1	3	1	1	1
CO2	Apply statistical inference techniques to draw conclusions from experimental data.	1	3	1	1	3	1
CO3	Analyze variance (ANOVA) technique and apply it to experimental design and interpretation of results	1	1	3	1	1	1
CO4	Illustrate skills in linear regression modeling and interpret regression models for engineering applications	2	1	3	1	1	1
CO5	Apply statistical principles to experimental design and assess model adequacy for regression models.	1	1	1	1	3	1
Practical							
CO1	Recall and apply foundational statistical concepts in practical data analysis using software tools like Minitab.	1	1	2	2	3	2
CO2	Demonstrate proficiency in conducting hypothesis tests, constructing confidence intervals, and analyzing experimental data using software.	3	2	2	2	3	2
CO3	Analyze regression models, interpret their coefficients, and evaluate model adequacy through diagnostic plots and statistical tests using software.	2	1	1	2	3	2
Average CO		1.80	1.40	2.00	1.40	2.30	1.40

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CX25C03 **Industrial Instrumentation** L T P C
3 0 0 3

Objectives:

- To enable the students to understand importance and measuring methods of various measurement parameters.
- To enable the students to understand and apply suitable instruments for measuring temperature, humidity and others.
- To enable the students to apply suitable analytical instruments for analyzing different samples.
- To enable the students to understand the necessity of controllers and sensors in measuring devices.
- To enable the students to analyze the industrial application and positioning of the measuring instruments.

Introduction

Introduction – Variables, Units & standards of measurement, Measurement terms –characteristic. Data Analysis - why are the measurements of these parameters important in industry? Different methods for measurement of motion parameters: Displacement, velocity, acceleration, vibration, torque, force etc. Measurement of straightness, flatness, roundness and roughness. Typical case study/design example: Instrumentation system for motion measurement in industry.

Measuring Instruments

Process Variables Measurement–Temperature systems– Thermocouples, Thermo resistive system, Filled-system thermometers, Radiation thermometry, Location of temperature measuring devices in equipments, Pressure system – Mechanical pressure elements Pressure Transducers and Transmitters, Vacuum measurement, Resonant wire pressure Transducer, Flow system – Differential producers, Variable area flow meters, Velocity, vortex, mass, ultrasonic & other flow meters, positive displacement flow meters, Open – channel flow measurements, Force systems, Strain gauges Humidity Moisture system, Humidity Measurement, Moisture measurement system, Rheological system, Viscosity measurement, Radiation system, Nuclear radiation instrumentation.

Analytical Instruments

Analytical instrumentation – Analysis instruments, Sample conditioning for process analyzers, X-ray Analytical methods, Quadrupole mass spectrometry, Ultra violet Absorption Analysis, Infra-red process analyzers, Photometric reaction product analyzers, Oxygen analyzers, Oxidation – reduction potential measurements, pH measuring systems, Electrical conductivity and Resistivity measurements, Thermal conductivity, gas analysis, Combustible, Total hydro carbon, and CO analyzer, Chromatography

Controllers and Sensors

Fundamentals of Automatic process control – Control algorithms-Automatic controllers – Electronic controllers -Electric controllers (Traditional) - Hydraulic controllers – Fluidics - Programmable controllers. Sensors, Transmitters and control valves - Pressure, Flow, Level, Temperature and Composition sensors, Transmitters, Pneumatic and electronic control valves, Types, Actuator, accessories, Instrumentation symbols and Labels.

Industrial Safety and Specifications

Safety: Introduction, electrical hazards, hazardous areas and classification, Non-hazardous areas. Enclosures – NEMA types, fuses and circuit breakers, protection methods: purging, explosion proofing and intrinsic safety. Specification of instruments, preparation of project documentation, process flow sheet, Instrument index sheet, Instrument specification sheet, panel drawing and specifications.

Course outcomes:

CO1 List different process variables and their measurement units.
CO2 Recognize and recall the principle and working of various process variable measuring instruments.
CO3 Describe the principle, working and range of various analytical instruments.
CO4 Explain the role of controllers and sensors in industrial instrumentation.
CO5 Rate the need of safety and specifications in Industries.

Text Books:

1. R.K.Jain, “Mechanical and Industrial Measurements”, Khanna Publishers, New Delhi.
2. C. D. Johnson, “Process Control Instrumentation Technology”, PHI.
3. S.K. Singh, “Industrial Instrumentation and Control”, Tata McGraw Hill Publishing Ltd., New Delhi.
4. Measurement Systems, Ernest O Doebelin & Dhanesh N Manik, McGraw Hill Education; 6 edition (July 2017).
5. Principles of Industrial Instrumentation, D Patranabis, McGraw Hill Education; 3 edition (July 2017).
6. A Course in Electronic Measurements and Instrumentation, A.K. Sawhney, Dhanpat Rai & Co. (P) Limited (2015).
7. Instrumentation, Measurement and Analysis, B. C. Nakra and K. K. Chaudhary, McGraw Hill Education India Private Limited; Fourth edition (1 August 2016).

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes					
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	List different process variables and their measurement units.	3	3	3	1	2	2
CO2	Recognize and recall the principle and working of various process variable measuring instruments.	3	3	3	1	2	2
CO3	Describe the principle, working and range of various analytical instruments.	3	3	3	1	2	2
CO4	Explain the role of controllers and sensors in industrial instrumentation.	3	3	3	1	2	2
CO5	Rate the need of safety and specifications in Industries.	3	3	3	1	2	2
	Overall CO	3	3	3	1	2	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

ES25001 **Ecology and Environment** L T P C
3 0 0 3

Objectives

- To enable students to learn about the structural and functional interactions between the ecological systems
- To inculcate knowledge about the duties of eco technologists
- To enable students to understand how engineering principles can solve ecological problems
- To enable students to understand the various waste management techniques in ecosystems
- To impart knowledge on how society affects the environment.

Introduction to Ecology and Ecosystems

Iintroduction to Ecology- Ecological Engineering and Eco technology and their relevance to human civilization. A Perspective on the Relationship Between Engineering and Ecology. Development and evolution of ecosystems – Sustainable Ecosystems; Principles and concepts pertaining to communities in the ecosystem - Energy flow and material cycling in ecosystems; Productivity in ecosystems.

Ecotechnology and Human Interactions

Ecological Engineering: A New Paradigm for Engineers and Ecologists. Classification of eco-technology - Principles and components of Systems and Modeling; Structural and functional interactions in environmental systems. Human modifications of environmental systems; The Ecological Effects of Stress; Designing Sustainable Ecological Economic Systems.

Ecological Engineering

Self-organizing processes - Multiple seeded microcosms; Interface coupling in ecological systems; Concept of energy; Adapting ecological engineering systems to potentially catastrophic events; Engineering Studies Based on Ecological Criteria; Agroecosystems - Determination of sustainable loading of Ecosystems.

Waste Management In Ecosystems

Principles and operation of soil infiltration systems - wetlands and ponds; source separation systems aquacultural systems; Engineering for Development in Environmentally Sensitive Areas-Oil Operations in a Rain Forest, detritus-based treatment for solid wastes. Applications of ecological engineering marine systems; Ecosystem classification and hydro-ecological modelling for national water management.

Society to Ecosystem

Ecological Effects of Warfare; ecological effects due to climate change; Effects of Stress on Ecosystem Structure and Function; Case studies of integrated ecological engineering systems.

Course Outcomes

CO1 Review the fundamentals of ecological systems and their relation with engineering and environment
CO2 Discuss the principles in the modeling of environmental systems and design of ecological economic systems
CO3 Formulate engineering studies based on ecological criteria
CO4 Explain the principles and applications in the water management system
CO5 Analyze the concept of various systems and their human modification

References

1. Peter C. Schulze, Engineering within ecological Constraints, National academy of engineering national academy press Washington, D.C. 1996
2. Bill Freedman, Environmental Ecology, 1st Edition, Academic Press, 1989.
3. Ignaci Muthu S, 'Ecology and Environment' Eastern Book Corporation, 2007.
4. Krebs, Charles J. 2001. Ecology: The Experimental Analysis of Distribution and Abundance. 5th edition.
5. Mitsch, J.W. and Jorgensen, S.E., Ecological Engineering, An Introduction to Ecotechnology, John Wiley & Sons, New York, 1989.
6. Ecology and Environment, 1st Edition. R.N Bhargava, V. Rajaram, Keith Olson, Lynn Tiede, CRC press, 2018.

COURSE ARTICULATION MATRIX

Course Outcomes	PROGRAM OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	2	-	1	-
CO2	-	-	3	-	-	2
CO3	-	-	3	2	-	1
CO4	2	-	3	-	3	1
CO5	1	1		-	-	3
AVERAGE CO	**2**	**2**	**2**	**2**	**2**	**1.75**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

ES25002 **Environmental Risk Assessment** L T P C
3 0 0 3

Objectives

- To enable the students to develop a basic detailed understanding of environmental health and risk assessment and its role within the risk management process.
- To enable the students to learn about different risk assessment formats and their use in environmental health studies
- To enable the students to learn about the different models for environmental risk assessment studies.
- To enable the students to learn on the international standards and national policies on environmental risk
- To impart knowledge on risks, their assessment and management from historical case studies

Risk Assessment Background

Introduction to environmental risk assessment and available methodologies; Types of risks; quantitative risk assessment; Riskassessmentsteps;rapidriskanalysis;comprehensiveriskanalysis.

Stages Of Environmental Risk Assessment

Hazard identification and control; Hazard assessment (consequence analysis); probabilistic hazard assessment (Fault tree analysis); Risk evaluation; Risk management

Standards and Policies

Overall risk contours for different failure scenarios; disaster management plan; emergency planning;riskmanagementISO14000; government policies to manage environmental risk.

Modelling

Safety me asures design in process operations; Accidents modeling–release modeling, toxic release and dispersion modeling, fire and explosion modeling, EMS models.

Health Risk Assessment and Case Studies

Health risk assessment; ecological risk assessment; Past accident analysis- Flux borough Mexico, Bhopal analysis; case studies.

Course Outcomes

CO1 Review the concept of environmental risk assessment

CO2 Identify Hazard, asses, evaluate and control

CO3 Compare between environmental risk assessment and disaster management plan and to understand government guidelines and policies

CO4 Design Safety measures and various models used in process operations.

CO5 Classify types of risk assessment and to study previous accident case studies and Apply knowledge obtained for reducing the risk in workplace

References:

1. Crowl, D.A and Louvar,J.F., Chemical process safety; Fundamentals with applications, Prentice Hall publication inc., 2002.
2. Houstan,H.B., Process safety analysis, Gulf publishing company, 1997
3. John Voorhees, Robert A. Woellner, International Environmental Risk Management: ISO 14000 and the Systems Approach, 1st edition, CRC Press; 1997
4. Trevor Kletz, Learning from Accidents, 3rd edition, Gulf professional publishing, 2001
5. Ted Simon, Environmental Risk Assessment: A Toxicological Approach, CRC press, 2019

Course articulation matrix:

Course outcomes	PROGRAMOUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	1	3	-	-	1
CO2	-	2	3	-	1	2
CO3	-	1	3	-	1	3
CO4	-	2	3	2	2	3
CO5	-	2	3	2	2	3
Average CO	**-**	**1.6**	**3**	**2**	**1.5**	**2.4**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

ES25003 **Risk Analysis and Hazop** L T P C
3 0 0 3

OBJECTIVES

- To impart knowledge on about risks involved in working premises
- To enable the students to quantify the risk and modeling the identified risks
- To impart knowledge on to make decisions from risk analysis models.
- To enable the students to understand the risk management using case studies
- To impart knowledge on to analyze the hazop study using industrial situations

Introduction to Risk Analysis
Risk analysis introduction, quantitative risk assessment, rapid risk analysis – comprehensive risk analysis-emission and dispersion-leak rate calculation. Single and two-phase flow dispersion model for dense gas-flash fire–plume dispersion-toxic dispersion model–evaluation of risk.

Radiation And Communication
Radiation – tank on fire –flame length – radiation intensity calculation and its effect on plant, people & property radiation – explosion due to over pressure-effects of explosion, risk contour-effects explosion, BLEVE-jet fire-fire ball, Risk perception, law, politics and risk communication.

Risk Analysis nd Management
Overall risk analysis-generation of metrological data-ignition date-population data consequences analysis and total risk analysis-overall risk contours for different failure scenarios-disaster management plan-emergency planning-n site & off site emergency planning, risk management ISO 140000, EMS models case studies-marketing terminal, gas processing complex, refinery

Safety Audits
Hazard identification safety audits, checklist, what if analysis, vulnerability models event tree analysis, fault tree analysis, Past accident analysis: Fixborough-Mexico-Bhopal analysis-Seveso-Chernobyl disaster.

Hazop Study
Hazop-guide words, parameters, derivation-causes-consequences-recommendation, Hazop study- case studies-pumping system-reactor-mass transfer system- system design, Industrial Hygiene.

Course Outcomes

CO1 Classify the types of risks arising in working environment
CO2 Defining the concept of explosion and its effects
CO3 Recognize and recall the knowledge of disaster management.
CO4 Explain the awareness of checklist and audits
CO5 Discuss hazop and its consequences and be able to create hazard free working premises

References:

1. Crowl,D.A and Louvar,J.F., Chemical process saftery; Fundamentals with applications, prentice hall publication inc., Fourth edition 2019.
2. Marcel, V.C., Major Chemical Hazard-Ellis Harwood Ltd., Chi Chester, UK, 1987.
3. Skeleton, B., Process Safety Analysis, Institution of Chemical Engineers, U.K., 1997.
4. Khan,F.I and Abbasi,S.A., Risk assessment of chemical process industries; Emerging technologies, Discovery publishing house, New Delhi, 1999.
5. Houstan,H.B., Process safety analysis, Gulf publishing company, 1997.
6. David Vose., Risk Analysis : A Quantitative Guide., Wiley- Third edition 2011

Course Articulation Matrix

Course Outcomes	PROGRAMOUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	3	1	2	1	1
CO2	2	1	2	2	2	1
CO3	2	3	1	2	3	1
CO4	3	1	1	3	2	1
CO5	1	2	1	1	2	1
Average CO	**2**	**2**	**1.2**	**2**	**2**	**1**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

ES25004	Environmental Nanotechnology	L T P C 3 0 0 3

OBJECTIVES

- To enable the students tostudy the basic terminologies and concepts of nanotechnology
- To impart knowledge on the most common bottom-up and top-down processes for the synthesis of nanomaterials and choose the appropriate process for a given application
- To enable the students to study the fate and transport, nanomaterial toxicity, and ecological effects in natural and engineered environments.
- To impart knowledge on the role of nanomaterials in wastewater treatment applications
- To enable the students to study the environmental risk and toxicity analysis of nanomaterials in environment

Introduction to Environmental Nanotechnology

Properties of Nanomaterial- Major applications in nanotechnology-Type of nanoparticles- Types of Engineered Nanoparticles-Properties- Nanotechnology - Environmental Applications.

Nanomaterial Synthesis

Synthesis methods- Chemical- physical - biological methods; Characterization of nanoparticles; Nanocomposites - Classification of nanocomposite-Preparation of different types of nanocomposite- Nano-magnetite-Iron-carbon composite- Carbonaceous nanomaterial- Nanosorbent material- Graphene/ magnetite nanocomposite- Carbon nanotube/chitosan nanocomposite-- Starch/SnO_2 nanocomposite.

Nanoparticles In Wastewater Treatment

Introduction- Engineered nanoparticles in wastewater treatment Plants-Mechanisms of wastewater treatment using Nanoparticles-Types of nanomaterials applied in wastewater Treatment- Metal and Metal Oxide Nanoparticles for Water Decontamination; Metal based nano-adsorbents; Nanofiber membranes; Nanocomposite membranes; Nanosorbents

Applications In Waste Management

Waste remediation- Nanoporous polymers and their applications in water purification, Photo-catalytic fluid purification; Energy conversion; Hierarchical self-assembled nanostructures for adsorption of heavy metals, Nano-pesticide formulations, Nanoparticles for dye removal and water filtration

Nanoparticles: Health And Environmental Risk

Health Hazards-Toxicity of nanoparticle, Nanomaterial health effects, Environmental hazards; Nanomaterial releases to the environment; Fate and transport of nanomaterial in the environment; Analysis in environmental matrices- Release to environment; Eco toxicity and analysis of nanomaterial in the aquatic environment; Effect of Nanomaterial on Critical Ecosystem.

Course Outcomes:

Upon completion of the course, students will acquire knowledge on

CO1 Basic concept of nanotechnology and their applications
CO2 Synthesis of nano materials.
CO3 Mechanisms that define nanomaterial fate and transport, nanomaterial toxicity, and ecological effects in natural and engineered environments.
CO4 Application of nano materials for wastewater treatment.
CO5 Environmental health and risk.

.

References:

1. Environmental Nanotechnology: Implications and Applications,1st Edition - Nouha Turan, Güleda Engin, Mehmet Bilgili,October 25, 2022
2. .K, Mackay.C, Bergeson.L.L, Clough S.R, Nanotechnology and Environment, CRC Press, 2009.
3. Ram.M, Andreescu.S.E, Hanming.D, “Nanotechnology for Environmental Decontamination”, McGraw Hill, 2011
4. Environmental Nanotechnology: Applications and Impacts of Nanomaterials- Mark Wiesner, Jean-Yves Bottero,McGraw Hill
5. Handbook of Nanotechnology, Edi-Bharat Bhushan, Springer, 2004.

Course Articulation Matrix:

Course Outcomes	PROGRAM OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	1	-	-	-	-
CO2	-	-	1	-	-	-
CO3	-	-	-	-	-	1
CO4	-	2	3	-	-	1
CO5	-	2	1	-	-	1
Average CO	**-**	**1**	**1**	**-**	**-**	**0.6**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

ES25005 **Environmental Biotechnology** L T P C
3 0 0 3

Objectives

- To enable the students to understand the role of microbes and their metabolism
- To enable the students to understand the DNA cloning and mutation of microbes
- To enable the students to understand pollution of environment by air, water and soil and their control strategy
- To enable the students to analyze degradation of natural resources and degradation of biodiversity
- To enable the students to understand the various bio-remedies for different environmental damages

Microbes and Metabolism

Environmental Biotechnology: Perceptions, Reality, and Applications, microbes in the service of mankind, microbes remediation of contaminated lands and water, microbes in the management of waste water, microbial composting of solid wastes, metabolic pathways of particular relevance to environmental biotechnology, production of cellular, fermentation and respiration

DNA Technology

Concept of DNA technology - plasmid - cloning of DNA - mutation - construction of microbial strains. Environmental effects and ethics of microbial technology - safety of genetically engineered organisms

Pollution and Pollution Control

Classification of pollutants, pollution control strategies, practical toxicity issues, practical applications to pollution control: Bio filters, bio trickling filters, advances in biogas technology, bio scrubbers and other options, process changes in different pollutants generating industries. Microbial migration – Soil – Acoustic, micro-organisms in pollution control.

Bioremediation

Bioremediation: Remediation methods, Techniques, suitability of bioremediation, factors affecting bioremediation, Technical, Economic, and Regulatory Future for Bioremediation: An Industry Perspective, Biodegradation of solid wastes. Selection of environmental biotechnology viable in field - scale waste Treatment Applications. Bio nanofertilizers, Vermiculture Biotechnology: vermiculture for sustainable agriculture and solid waste management. Plastic and Polyethene degrading microbes – Microbial leaching.

Biotechnolgy Remedies For Environmental Damages

Biotechnological remedies for environmental damages - decontamination of ground water systems – subsurface environment - reclamation concepts. Degradation of high concentrated toxic pollutants - non-halogenated, halogenated - Petroleum hydrocarbons – Pseudomonas putida for EOR/Oil Spills - metals. Mechanisms of detoxification, oxidation reactions, dehalogenation - biotransformation of metals. Microbial cell/enzyme technology – adapted microorganisms - biological removal of nutrients – microalgal biotechnology. Role of Microbial Biotechnology in Sustainable development, Regulatory bodies – ISO 14001:2016.

Course Outcomes:

CO1 Review the concept of environmental biotechnology and the different types of microbes used.
CO2 Recognize on the basics of DNA, their impact on environment and the ethics of microbial technology.
CO3 Classify the different pollutants and identify the appropriate control strategy.
CO4 Apply knowledge on the bioremediation strategies for decontamination and detoxification of environmental systems.
CO5 Assess biotechnology remedies involved in biotransformation of pollutants and generation of energy.

References:

1. Vipin Kumar Er. Pramod Kumar And Er. Vipin Kumar, “Textbook of Environmental Biotechnology”, Woodhead Publishing, 2009.
2. P. K. Mohapatra, “Textbook of Environmental Biotechnology”, I K International Publishing, 2006.
3. Fulker M.H. Environmental Biotechnology, CRC Press, 2010.
4. Wainwright, M, An Introduction to Environmental Biotechnology, 1999.
5. Martin, A.M., Biological Degradation of Wastes, Elsevier Appl. Science, New York,1991.
6. 6.Gray, S.S., Fox, R and James W. Blackburn Environmental Biotechnology for Waste Treatment, Plenum Press, New York 1991.
7. 7.Rittmann, B.E, Seagren, E., Wrenn, B. A and Valocchi A.J, Ray, C and Raskin, L Insitu Bioremediation (2nd Ed.) Nayes Publ. U.S.A. 1994.
8. Old, R.W., and. Primrose, S.B., Principles of Gene Manipulation (3rd Ed.), BlackwellSci. Pub, Cambridge, 1985.

Course Articulation Matrix

Course Outcomes	PROGRAM OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	1	3	3
CO2	3	3	3	1	3	3
CO3	3	3	3	1	3	3
CO4	3	3	3	1	3	3
CO5	3	3	3	1	3	3
AVERAGE CO	**3**	**3**	**3**	**1**	**3**	**3**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

ES25006 **Waste Management and Energy Recovery** L T P C
3 0 0 3

Objectives

- To enable students to understand of the concept of Waste to Energy.
- To link legal, technical and management principles for production of energy form waste.
- To know the best available technologies for waste to energy
- To analyse the success and failures analysis of case studies and develop the skills in the decision making
- To identify the various sources of waste generation its potential for energy production

Waste and Waste Management Legislation

Waste -Definition-Sources –Sources of waste- domestic, industrial, agriculture, hazardous and non-hazardous. Types of Waste-Waste Generation – analysis of waste Characteristics-Classification of waste as source of Fuel- Industrial waste - MSW – Agro –Biomass- assessment of Energy Recovery Potential. Indian legislation on management and handling of different waste –hazardous wastes, biomedical wastes, electronic wastes, construction and demolition wastes, plastics and Other Special Wastes rules.

Waste Management

The Logistics of solid Waste Collection-Principles of Waste Management and Waste Utilization-Waste Management Hierarchy and 3R Principle of Reduce, Reuse and Recycle. Protocol for Evaluation of Technology for Waste Management.

Waste to Energy Technologies

Technologies for Waste to Energy- Biochemical Conversion – Energy production from organic waste through anaerobic digestion and fermentation. Thermo-chemical Conversion – Combustion, Incineration and heat recovery, Pyrolysis, Gasification; Plasma Arc Technology and other newer technologies.

Waste to Energy Options & Environmental Implications

Energy Production from Plastic - Solid Waste Refuse Derived Fuel (RDF) – Alternate Fuel Resource (AFR). Landfills: Gas generation and collection in landfills, Introduction to transfer stations. Environmental standards for Waste to Energy Plant operations and gas clean-up. Savings on non-renewable fuel resources. Environmental assessment of proposed waste to energy plant. Carbon Credits: Carbon foot calculations and carbon credits transfer mechanism

Case Studies

Forecasting of waste-to-energy system - Success/failures of waste to energy- Global Best Practices in Waste to energy production distribution and use. Indian Scenario on Waste to Energy production distribution and use in India. Success and Failures of Indian Waste to Energy plants. Role of the Government in promoting ‘Waste to Energy’

Course Outcomes

On successful completion of this course, the student will able to

CO1 Classify the various sources of waste generated and examine its potential for energy production

CO2 Be capable of linking legal, technical and management principles for production of energy form waste.

CO3 Identify the best available technologies for conversion different wastes to energy.

CO4 Assess the carbon credits and environmental impacts of waste to energy plant

CO5 Analyse the case studies and develop the decision making skills to forecast success of waste to energy techniques.

References:

1. Tchobanoglous, Theisen and Vigil, Integrated Solid Waste Management, 2d Ed.McGraw-Hill, New York, 1993.:
2. Howard S. Peavyetal, Environmental Engineering, McGraw Hill International Edition, 1985
3. Stanley E. Manahan. Hazardous Waste Chemistry, Toxicology and Treatment, Lewis Publishers, Chelsea, Michigan, 1990
4. Parker, Colin and Roberts, Energy from Waste – An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985.
5. Manoj Datta, Waste Disposal in Engineered Landfills, Narosa Publishing House, 1997.
6. P. Jayarama Reddy, Municipal Solid Waste Management Processing - Energy Recovery - Global Examples, Published November 30, 2011 by CRC Press

Course Articulation Matrix

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	-	3	3	3
CO2	3	-	-	3	3	3
CO3	3	-	2	3	3	3
CO4	3	2	2	3	3	3
CO5	3	-	1	3	3	3
AVERAGE CO	**3**	**2**	**1.6**	**3**	**3**	**3**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

ES25007 **Green Chemistry and Engineering** L T P C
3 0 0 3

OBJECTIVES

- To make the students aware of principles of green chemistry, Engineering and sustainability.
- To impart knowledge on global environmental issues, need of risk assessment.
- To provide knowledge on pollution prevention and property estimation.
- To learn about evaluation exposure and green chemical synthesis pathways.
- To make the students understand about the methods available for flow sheet analysis and life cycle assessments

Introduction to Green Chemistry

Understanding the issues; Green Chemistry – Definition, Principles of Green Chemistry and Examples; Green Chemistry Methodologies; Green Engineering – Definition, Principles of Green Engineering; Initiatives Taken Up by Countries Around the World; The Green Chemistry Expert System case studies; Principles of Sustainability; The Sustainable Process Index

Environmental Issues and Risk Assessment

Role of chemical processes and chemical products; An overview of Major Environmental Issues; Global Environmental Issues; Air Quality Issues; Water Quality Issues; Ecology, Natural Resources, Description of Risk; Value of Risk Assessment in the Engineering Profession; Risk-Based Environmental Law; Risk Assessment Concepts; Hazard Assessment, Dose Response, Exposure Assessment, Risk Characterization.

Pollution Prevention and Property Estimation

Pollution Prevention Concepts and Terminology; Responsibilities for chemical process safety; Responsibilities for environmental protection, Chemical and Physical Property Estimation; Estimating Environmental Persistence; Estimating Ecosystem Risks; Using Property Estimates to Estimate Environmental Fate and Exposure; Classifying Environmental Risks Based on Chemical Structure

Evaluating Exposures

Occupational Exposures - Recognition, Evaluation and Control; Exposure Assessment for Chemicals in the Ambient Environment; Designing Safer Chemicals; Quantitative / Optimization - Based Frameworks for the Design of Green Chemical Synthesis Pathways; Green Chemistry Pollution Prevention in Material Selection for Unit Operations; Reactors, Separation Devices, Storage Tanks and Fugitive Sources.

Flow Sheet Analysis and Life Cycle Assessment

Process Energy Integration; Process Mass Integration; Case Study of a Process Flow sheet; Estimation of Environmental Fates of Emissions and Wastes; Introduction to Product Life Cycle Concepts - Life-Cycle Assessment, Life-Cycle Impact Assessments, Streamlined Life-Cycle Assessments, Uses of Life-Cycle Studies; A Framework for Evaluating Environmental Costs

Course Outcomes

CO1 Recognize the basic principles of green chemistry, engineering and sustainability.
CO2 Explain the major environmental issue and risk assessment.
CO3 Recall pollution prevention and estimate the environmental fate and exposure.
CO4 Evaluate exposure pathways and design of green chemical synthesis pathways.
CO5 Analyse flow sheeting and life cycle assessment

References:

1. Allen, D.T., Shonnard, D.R, Green Engineering: Environmentally Conscious Design of Chemical Processes. Prentice Hall PTR 2002.
2. Anne E. Marteel-Parrish, Martin A. Abraham, GREEN CHEMISTRY AND ENGINEERING: A Pathway to Sustainability, John Wiley & Sons, Inc., 2014.
3. Mukesh Doble and Anil Kumar Kruthiventi, Green Chemistry and Engineering, Elsevier, Burlington, USA, 2007.
4. Hand Book of Green Chemistry and Technology; by James Clarke and Duncan Macquarrie; Blakwell Publishing
5. Anastas, P. T., Warner, J. C. Green Chemistry: Theory and Practice, Oxford University Press Inc., New York, 1998.
6. Matlack, A. S. Introduction to Green Chemistry Marcel Dekker: New York, NY, 2001
7. Bishop P. L., Pollution Prevention: Fundamentals and Practice McGraw-Hill, Boston, 2000

COURSE ARTICULATION MATRIX:

Course Outcomes	PROGRAM OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	3	3	3	3
CO2	2	2	3	3	3	3
CO3	2	2	3	3	3	3
CO4	2	2	3	3	3	3
CO5	2	2	3	3	3	3
Average CO	**2**	**2**	**3**	**3**	**3**	**3**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

ES25008 **Environmental Sustainability** L T P C
3 0 0 3

Objectives:

- To impart knowledge on to understand the concept of environment
- To enable the students to analyse the causes and effects of 'environmental degradation' and 'resource depletion'
- To impart knowledge on to understand the nature of environmental challenges facing our country
- To enable the students to relate environmental issues to the larger context of sustainable development.
- To enable the students for Valuing environment and economic development without depletion of natural resources.

Valuing the Environment
Valuing the Environment: Concepts, Valuing the Environment: Methods, Property Rights, Externalities, and Environmental Problems

Sustainable Development
Sustainable Development: Defining the Concept, strategies of sustainable development- uses of conventional and non-conventional sources of energies The Population Problem, Natural Resource Economics: An Overview, Energy, Water, Agriculture

Air Pollution
Biodiversity, Forest Habitat, Commercially Valuable Species, Stationary-Source Local Air Pollution, Responsibility for net emissions of greenhouse gases, Acid Rain and Atmospheric Modification, Transportation

Water Pollution
Water Pollution, Solid Waste and Recycling, Toxic Substances and Hazardous Wastes, Global Warming.

Visions of Future
Resource dependence and development, Poverty and the Environment, Visions of the Future.

Course Outcomes:
CO1 Explain valuing the environment and externalities to environmental problems.
CO2 Defining the concept of sustainable development
CO3 Recall the concepts of biodiversity and air pollution.
CO4 Analyze about water pollution and its hazards.
CO5 Discuss about the visions of the future development, poverty, and environment.

References:

1. Andrew Hoffman, Competitive Environmental Strategy-A Guide for the Changing Business Landscape, Island Press.
2. Stephen Doven, Environment and Sustainability Policy: Creation, Implementation, Evaluation, The Federation Press, 2005.
3. Tom Tietenberg, Environmental economics and policy 6th Edition, Pearson Education, 2010
4. Jennifer A. Elliott, An Introduction to Sustainable Development Third edition, Taylor & Francis, 2006.
5. Stephen Doven, Environment and Sustainability Policy: Creation, Implementation, Evaluation, The Federation Press, 2005

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	3	2	3	2	2
CO2	2	3	3	3	2	1
CO3	3	2	3	3	3	2
CO4	2	2	2	2	2	1
CO5	2	3	3	3	2	3
AVERAGE CO	**1.8**	**2.2**	**2.8**	**2.8**	**1.8**	**1.5**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

ES25009 Principles of Cleaner Production L T P C
3 0 0 3

Objectives

- To enable students to know the importance, and different approaches of cleaner production in industries
- To impart knowledge on environmental management tools applying cleaner production principle.
- To inculcate knowledge on energy and material balances for cleaner production assessment
- To make student understand about life cycle analysis and prevention methods
- To enable students to know about industrial application of cleaner production

Introduction

Sustainable Development – Indicators Of Sustainability – Sustainability Strategies – Barriers To Sustainability–Industrial Activities And Environment– Industrialization And Sustainable Development –IndustrialEcology–CleanerProduction(CP)inAchievingSustainabilityPrevention Versus Control Of Industrial Pollution – Environmental Policies And Legislations –Regulation To Encourage Pollution Prevention And Cleaner Production – Regulatory Versus Market Based Approaches, Carbon and Water Footprint.

Cleaner Production

Definition – Methodology – Historical Evolution – Benefits – Promotion – Barriers – Role of Industry, GovernmentAndInstitutions–EnvironmentalManagementHierarchy– RelationOfCPAndEMS–Integrated Prevention And Pollution Limitation – Best Available Technology Concept (BAT) – Internet Information & Other CP Resources

Qualitative phase behaviour of hydro cleaner production project development & Implementation

Overview Of CP– Assessment Steps And Skills– Preparing For The Site, Visit, Information Gathering, And Process Flow Diagram – Material Balance – CP Option Generation –Technical And Environmental Feasibility Analysis – Economic Valuation Of Alternatives – Total Cost Analysis – CP Financing – Establishing A Program –Organizing A Program – Preparing A ProgramPlan– MeasuringProgress–PollutionPreventionAndCleanerProductionAwarenessPlan.

Support instruments of Prevention methods

Life Cycle Analysis–Elements Of LCA–Life Cycle Costing–Eco Labelling–Design For The Environment – Circular Economy - International Environmental Standards – ISO 14001 – Environmental Audit –Environmental Statement.

Case Studies
Industrial Applications of CP, LCA, EMS And Environmental Audits.

Course Outcomes
CO1 Discuss the evolution of corporate environmental management strategies
CO2 Explain cleaner production measures applicable to different industries
CO3 Prepare energy and material balances for processes as part of a cleaner production assessment.
CO4 Review of strategies and technologies for a cleaner industrial production
CO5 Recall the relation to the concept of sustainable development.

Reference Books

1. Paul L. Bishop, Pollution Prevention: Fundamentals and Practice", McGraw Hill International, 2000.
2. Prasad ModakC. Visvanathan and Mandar Parasnis, Cleaner Production Audit", Environmental System Reviews, No.38, Asian Institute of Technology, Bangkok, 1995.
3. Francisco J G Da Silva, Ronny M G," Cleaner production towards a better future", First Edition, Springer , 2020
4. Anand R, Babu,D and Vinoth T," Advances in clean Energy Production and application" First Edition CRC Press,2020
5. World Bank Group "Pollution Prevention and Abatement Handbook– Towards Cleaner Production", World Bank And UNEP, Washington D.C.,1998.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	-	2	-	1
CO2	-	-	-	-	-	-
CO3	-	-	-	2	-	-
CO4	-	-	2	3	-	1
CO5	-	-	3	3	-	-
AVERAGE CO	-	-	1.3	1.5	-	0.8

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

ES25010 Advanced Oxidation Processes and Technology L T P C
3 0 0 3

Objectives:

- To enable students aware of the techniques used for treating wastewater by Advanced Oxidation Processes (AOP)
- To impart knowledge on various technology to control emissions.
- To enable students to learn the various types of AOP and their mechanism
- To enable students to learn the heterogeneous AOP and its applications
- To enable students to understand the various characterization techniques in AOP

Overview Of AOP

Introduction to AOP, fundamentals of AOPs, Types of AOP in treating contaminant in waste water.

Types of AOP And Its Mechanism

Photo induced AOP, UV Photolysis H2O2, UV/O3 processes, Ozonation, Fenton processes, Ultrasound processes and principles of sonochemistry

Photo Based AOP Processes

Photochemistry, photolysis, photo-catalytic reactions, mechanism of photo-catalytic reaction, fundamentals of semiconductor photocatalyis, types of photocatalyst. Photo electrocatalysis process: photo oxidation reactions, photo-initiated oxidations, photomineraliztion of organic matter in water and air, aqueous systems. Sono catalysis.

Heterogenous AOP

AOP processes for water and wastewater treatment,. Fenton processes: homo and heterogeneous process, effect of system composition and process, identification of degradation products

Application and Characterization

Application of AOPs for VOC reduction, biologically toxic or non-degradable and odour treatment, Case studies - textile , pharmaceuticals and petroleum industries Characterization techniques XRD, SEM,TEM,UV-DRS,FTIR

Course Outcomes

CO1 Review the fundamentals of AOP.
CO2 Classify the types of AO Pandits mechanism.
CO3 Identify the various photo induced techniques in AOP
CO4 Compare various types of heterogeneous AOP
CO5 Analyzing various characterization techniques in AOP.

Reference Books

1. Simon Parsons, “Advanced oxidation processes for water and wastewater treatment”, IWA Publishing, 2004.
2. Thomas Oppenländer, “Photochemical Purification of Water and Air: Advanced Oxidation Processes(AOPs):Principles,ReactionMechanisms,ReactorConcepts”,Wiley-VCHPublishing,Publishedby,2003.
3. Harold J.Ratson, “Odor and VOC Control Handbook”,Newyork, Mcgraw-hill,1998.
4. Vincenzo Belgiorno, Vincenzo Naddeoand Luigi Rizzo, “Water, Waste wate rand Soiltreatment by Advanced Oxidation Processes(AOP)”,LuluEnterprises,2011.
5. Subramanian Senthilkannan Muthu, Ali Khadir, “ Advanced Oxidation Processes in Dye Containing Waste Water“ , Springer 2022.

Course Articulation Matrix

Course Outcomes	PROGRAM OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	1	1	1	2	2
CO2	1	2	2	1	1	2
CO3	1	2	2	2	2	1
CO4	-	2	2	1	1	2
CO5	3	3	3	2	2	2
AVERAGE CO	**1**	**2**	**1.8**	**1.4**	**1.6**	**1.8**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

ES25011 Electrochemical Environmental Technology L T P C
3 0 0 3

Objectives

- To enable the students to understand wastewater characteristics and its importance
- To enable the students to understand basic mechanism in electrochemical cell
- To facilitate the student to learn basic electrochemical techniques to treat the gas, liquid and soil pollutant.
- To impart knowledge about different electrochemical reactors in treating wastewater
- To make the students analyze the application of electrochemical engineering in various industries

Electrochemistry
Definition and classification of pollutants, Physical and chemical Characteristics of wastewater, method of pollutants analysis role of sensors in environmental pollution. Introduction to Electro chemistry and Electrochemical Engineering. Electrochemical potential- Butler-Volmer, Tafel equation

Electrochemical Process and Its Importance
Conventional methods for pollution control, incinerator, pyrolysis, air stripping, microbial treatment, precipitation coagulation, adsorption, membrane process. Advanced techniques of pollution treatment, Direct electro oxidation, Indirect electro oxidation, , Advantages of Electro oxidation Process, pollutant treatment using electro oxidation process, Electro coagulation process, Advantages of electro coagulation process, Electro flotation process, Application of electrochemical process for waste water treatment.

Photoelectrochemical Reactor
Comparison of Chemical and Electrochemical Process- Production of hydrogen by water electrolysis. current efficiency, selectivity and energy consumption for electro organic synthesis. Photo- electrochemical cells for conversion of light energy to electrical energy- Photo electrochemical Conversion mechanism. Pollutant treatment using photo electrochemical reactor

Types of Electrochemical Reactor
Electrochemical reactors; two dimensional and three dimensional electrodes; Tank cell- Filter press cell-Packed bed – Fluidized bed electrochemical reactor-Applications; Batch; Continuous Stirred Tank Electrochemical Reactor and Plug flow electrochemical Reactor- Design Equation. Modeling of batch with recirculation, Electro oxidation-Electro coagulation, Application of electrochemical reactors for waste water treatment.

Hybrid Electrochemical Reactor
Application of AOPs for VOC reduction, biologically toxic or non-degradable and odour treatment, Case studies - textile , pharmaceuticals and petroleum industries Characterization techniques XRD, SEM,TEM,UV-DRS,FTIR

COURSE OUTCOMES
CO1 Report the physical and chemical characteristics of waste water and their measurement
CO2 Discuss basic electrochemical engineering concept to treat the industrial pollutants
CO3 Compare various photoelectrochemical method for treating pollutant
CO4 Classify various electrochemical processes in wastewater treatment.
CO5 Analyze various hybrid electrochemical reactors used in industries.

Reference Books

1. Scott,K., “Electrochemical Process for Cleaner Technology” ,Academic Pres,1990.
2. Kirkwood,R. C. And Longley,A.J., “Clean Technology and Environment”, Chapman & Hall, 1995.
3. Rajeshwar, K.andIbanez,J.G., “Environmental Electrochemistry”, Academic Pre,1997.
4. Pletcher, D.,andWalsh,F., “Industrial Electrochemistry”, 2Edition Chapmanand Hall,1990.
5. Keith B.Oldham, Jan C Myland,” Electrochemical Science and Technology, Fundamentals and application”, Wiley 2011.

Course Articulation Matrix

Course Outcomes	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	2	2	1	2	2
CO2	2	2	2	2	2	2
CO3	2	2	2	2	2	2
CO4	2	2	2	2	2	2
CO5	2	2	2	2	2	3
AVERAGE CO	**1.8**	**2**	**2**	**1.8**	**2**	**2.2**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

ES25012 **Environmental Management** L T P C
3 0 0 3

Objectives:

- To impart knowledge on the various principles of environmental management
- To make the students aware of the importance of emission guidelines
- To enable the students to learn about the functions of EIA, environmental auditing
- To enable the students to learn and apply the various standards
- To facilitate the students to understand the design and economics of environment

Principles of Environmental Management
Introduction to environmental management- ecosystem concepts, participants in EM; ethics and environment, international environmental movement; environmental concerns in India

Political And Legal Aspects of Environmental Management
Introduction to Environmental policies- Environmental policies and programs in India; environmental law and legislation- environmental legislation in India

Environmental Impact Assessment & Auditing
EIA- documentation and process, general audit methodology, elements of audit process; waste audits & pollution prevention assessments; EA in industry

Environmental Management and System Standards
Environmental Management Systems; ISO 14000 Series; Environmental management techniques- environmental monitoring; environmental modelling- forecasting modelling, growth modeling, sensitivity analysis; applications of GIS and remote sensing in EM; eco-mapping..

Environmental Design & Economics
Principles of environmental design - ED for manufactured products; buildings & developmental planning; economics & environment- environmental valuation, economics of natural resources.

Course Outcomes

CO1 Review environmental legislation and strategies to control pollution
CO2 Explain standards, guidelines and pollution prevention policy
CO3 Discuss the standards for discharge of treated liquid effluent into water bodies and standards for disposal of air emissions
CO4 Identify occupational health and safety requirements
CO5 Write about environmental pollution monitoring and measurement & legislature requirements for industrial units in estates/complex

Reference Books:

1. Mike Russo., Environmental Management: Readings and Cases, 2 nd Edition, Sage Publications, 2008.
2. Canter, W.L., Environmental Impact Assessment, McGraw-Hill Inc., 1992
3. Rau, J.G and Wooten, D.C., Environmental Impact Analysis Handbook, McGraw-Hill, 1980.
4. Jain, R.K., Urban, L.V., Stacey, G.S. and Balbach, H.E., Environmental Assessment, McGraw- Hill, 1993
5. .B.N. Lohani, Environmental quality management, South Asian Publishers, New Delhi, 1984.

Course Articulation matrix:

Course Outcomes	PROGRAM OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	1	-	1	1
CO2	2	1	1	1	-	-
CO3	3	1	1	1	-	-
CO4	2	1	1	-	1	1
CO5	3	2	1	-	-	-
Average CO	**2.6**	**1.2**	**1**	**1**	**1**	**1**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

ES25013 Remote sensing and GIS applications in environmental Management L T P C
3 0 0 3

Objectives

- To impart knowledge on fundamentals of remote sensing
- To enable the students to learn the various technologies used in remote sensing
- To facilitate the students to interpret the data as obtained in remote sensing and GIS
- To impart knowledge about various GIS softwares and data analysis of GIS
- To enable the students to acquire knowledge on the concept of geographical information system. Application of remotes ensing and GIS in detail.

Overview of remote Sensing

Historical Perspective, Principles of remote sensing, components of Remote Sensing, Energy source and electromagnetic radiation, Energy interaction, Spectral response pattern of earth surface features.

Remote Sensing technology

Classification of Remote Sensing Systems, Energy recording technology, Aerial photographs, Photographic systems–A cross track and along track scanning ,Multispectral remote sensing, Thermal remote sensing, Microwave remote sensing – Active and passive sensors, RADAR, LIDAR, Satellites and their sensors, Indian space programme-Research and development.

Data Processing

Characteristics of Remote Sensing data, Photogrammetry – Satellite data analysis – Visual image interpretation, Digital image processing – image rectification, enhancement, transformation, Classification, Data merging, RS–GIS Integration, Image processing software.

Geographical Information System

GIS Concepts – Spatial and non-spatial data, Vector and raster data structures, Data Analysis, Database management–GIS software, GRASS-Geographic Resources Analysis Support System.

Remote Sensing and GIS applications

Monitoring and management of the environment, Conservation of resources, Sustainable land use, Coastal zone management –Limitations, GIS in Environmental Health and Environmental Impact.

COURSE OUTCOMES

CO1: Review the basic principles in remote sensing.
CO2: Compare the various classification and technology in remote sensing.
CO3: Recall and recognize the characteristic of remote sensing.
CO4: Evaluate the analyzing technique in remote sensing and GIS
CO5: Discuss the concept of geographical information system . Application of remotes ensing and GIS in detail.

Reference Books:

1. Gottfried Konecny, Geo information: Remote sensing, Photogrammetry and geographical Information Systems, CRCpress,1st Edition,2002.
2. Burrough, P.A. and McDonnell, R.A., Principles of Geographic Information systems Oxford University Press, New York,2001.
3. Lintz,J. andSimonet,RemotesensingofEnvironment,AddisonWesleyPublishingCompany,New Jersey,1998.
4. Pmapler and Applications of Imaging RADAR, Manual of RemoteSensing,Vol.2,ASPR,2001.
5. Shahid A. Abbasi, K. B. Chari Application of GIS and Remote Sensing in Environmental Management Discovery Publishing House, 2005

COURSE ARTICULATION MATRIX:

Course Outcomes	PROGRAM OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	1	-	1	1	2
CO2	1	2	1	2	2	3
CO3	1	2	1	2	2	3
CO4	2	2	2	3	3	2
CO5	2	2	2	3	3	3
AVERAGE CO	**1.4**	**1.8**	**1.2**	**2.2**	**2.2**	**2.6**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

ES25014 **Soil remediation technologies** L T P C
3 0 0 3

OBJECTIVES

- To facilitate students to understand the organic and inorganic geochemistry
- To impart knowledge on the various transport mechanism in soil
- To enable the students to learn in situ and ex situ soil treatment
- To inculcate knowledge on various technology in treating soil
- To acquaint the students with current techniques for soil remediation.

Overview of Soil Remediation

Soil description and soil classification; hydraulic and consolidation characteristics – chemical properties, soil pH ,surface charge and point of zero charge, anion and cation exchange; capacity of clays– specific surface area, bonding in clays-soil, pollution-factors governing soil pollutant interaction

Inorganic and Organic Geochemistry

Contaminant's description-contaminants properties, distribution of metals in soils; Geochemical processes controlling the distribution of metals in soils, chemical analysis of metal in soil; organic geochemistry – organic contamination; distribution of NAPLS in Soils – process controlling the distribution of NAPL Sin soil, chemical analysis of NAPLS in soils

Contaminant Fate and Transport in soil

Transport processes – advection, diffusion, dispersion ; chemical mass transfer-Processes sorption and desorption, precipitation and dissolution, oxidation and reduction, acid base reaction; complexation – ion exchange – volatilization – hydrolysis– biological process-microbial transformation of heavy metals

Remediation Technologies

In situ biological treatments –bioventing, enhanced bioremediation land farming natural attenuation phytoremediation; In sit physical / chemical treatments — electroreclamationsolidification/stabilizationlandfillcapandenhancementssoilflushingpolymeradsorption; Insituthermal treatments-soil vapour extraction, thermally enhanced vitrification

Ex Situ Treatments

Ex situ physical/chemical treatments-chemical extraction, solar detoxification; chemical reduction/oxidation- soil washing solidification/stabilization; soil vapor extraction; ex situ thermal treatment -shot gas de contamination thermal desorption plasma arc in cineration pyrolysis vitrification

COURSE OUTCOMES

CO1 Identify the soil and classify them, the effects of eenvironmental contamination and the various remediation technologies which may be employed
CO2 Recall the contamination and degradation caused by various types of urban, industrial and agricultural development
CO3 Analyze the transport processes in soil
CO4 Explain the various remediation technologies
CO5 Choose appropriate technology of soil contamination

References

1. Edward J. Calabrese, Paul T. Kostecki, James Dragun., Contaminated Soils, Sediments And Water: Successes And Challenges, Birkhäuser Publications, 2005
2. Martin n. Sara., site assessment and remediation handbook, second edition, lewis publishers, 2000
3. Calvin Rose, An Introduction To The Environmental Physics Of Soil, Water And Water Sheds, Cambridge University Press, 2004.
4. Paul Nathanail C. And Paul Bardos R., Reclamation Of Contaminated Land, John Wiley & Sons Limited, 2004.
5. William J. Deutsch, Groundwater Geochemistry: Fundamentals And Applications To Contamination, Lewis Publishers, 1997

Course Articulation Matrix

Course Outcomes	PROGRAM OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	1	1	1	2	2
CO2	-	-	-	2	1	-
CO3	-	-	-	2	2	-
CO4	-	1	-	-	1	-
CO5	-	1	1	-	1	2
AVERAGE CO	-	**1**	**1**	**1**	**1.4**	**2**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

ES25015	Environmental health and safety in industries	L T P C 3 0 0 3

OBJECTIVES

- To enable the students to know the safety acts, regulations and initiatives.
- To enable students to achive the insights of hazards and control measures.
- To facilitate students to attentive of place safety and safety systems.
- To impart knowledge on the procedure of investigating accidents.
- To facilitate students to realize the importance of education and training on safety management.

Overview Of Environmental Health and Safety

Need for developing Environment, Health and Safety systems in work places. Status and relationship of Acts, Regulations and Codes of Practice. Role of trade union safety representatives. International initiatives. Ergonomics and work place.

Occupational Health and Hygiene

Definition of the term occupational health and hygiene. Categories of health hazards. Exposure pathways and human responses to hazardous and toxic substances. Advantages and limitations of environmental monitoring and occupational exposure limits. Hierarchy of control measures for occupational health risks. Importance of PPE, Effects on humans, control methods and reduction strategies for noise, radiation and excessive stress.

Workplace Safety and Safety Systems

Features of the satisfactory design of work premises HVAC, ventilation. Safe installation and use of electrical supplies. Fire safety and first aid provision. Significance of human factors in the establishment and effectiveness of safe systems. Safe systems of work for manual handling operations. Control methods to eliminate or reduce the risks arising from the use of work equipment. Requirements for the safe use of display screen equipment. Procedures and precautionary measures necessary when handling hazardous substances, Emergency Preparedness plan

Techniques of Environmental Safety

Elements of a health and safety policy and methods of its effective implementation and review. Functions and techniques of risk assessment, inspections and audits. Investigation of accidents - Principles of quality management systems in health and safety management. Relationship between quality manuals, safety policies and written risk assessments. Records and other documentation required by an organization for health and safety. Industry specific EHS issues.

Education and Training

Requirements for and benefits of the provision of information, instruction, training and supervision. Improvement in effective training programmes. Principles and methods of effective training. Feedback and evaluation mechanism.

Course Outcomes

CO1 List the safety acts, regulations and initiatives.

CO2 Classify the categories of health hazards and control measures.

CO3 Recognize work place safety and control methods for risk reduction.

CO4 Evaluate risk assessment and understand the procedure of investigating accidents.

CO5 Discuss the importance of education and training on safety.

Reference Books

1. Nicholas P. Cheremisinoff and Madelyn L. Graffia , 'Environmental and Health and Safety Management', First Edition, William Andrew Inc. NY, 1995.
2. Daniel A. Crowl, Joseph F. Louvar, Chemical Process Safety- Fundamentals with Applications, Second Edition, Prentice Hall International Series in the Physical and Chemical Engineering Sciences.
3. Bill Taylor , 'Effective Environmental, Health, and Safety Management Using the Team Approach', Culinary and Hospitality Industry Publications Services 2005.
4. Raghavan, K.V and A.A Khan, Methodologies in Hazard Identification and Risk Assessment, Manual by CLRI., Dec, 1990
5.

COURSE ARTICULATION MATRIX:

Course Outcomes	PROGRAM OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	-	1	-	-	-
CO2	-	2	1	1	-	1
CO3	-	1	1	-	-	1
CO4	-	2	1	-	-	1
CO5	-	-	-	-	-	-
AVERAGE CO	**-**	**1.66**	**1**	**1**	**-**	**1**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively