DEPARTMENT OF CHEMICAL ENGINEERING

ANNA UNIVERSITY, CHENNAI-25

VISION:

To be recognized globally and to function as a catalyst in providing outstanding education, to develop engineers who will excel in academia, industry, and research, and to strive for sustainable technologies and societal needs.

MISSION:

1. To disseminate high-quality Chemical Engineering Education.
2. To develop quality engineers and technocrats with inter-disciplinary skills.
3. To collaborate with industries for innovative concepts/ideas.
4. To perform high-impact research for the benefit of society.

ANNA UNIVERSITY: : CHENNAI: 600 025
UNIVERSITY DEPARTMENTS
M. TECH. ENVIRONMENTAL SCIENCE AND TECHNOLOGY
REGULATIONS – 2023
CHOICE BASED CREDIT SYSTEM

1. PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

1.	Analyze and evaluate complicated environmental issues with defined solutions.
2.	Ability to apply scientific principles and engineering for sustainable development.
3.	Work collaboratively with diverse teams to develop effective solutions to complex environmental problems.
4.	Skills to create works that can be published in reputable publications and produce patented products.
5.	Demonstrate lifelong learning through continued professional development, and exhibit leadership in professional societies and organizations

2. PROGRAM OUTCOMES (POs)

PO	Program Outcomes
1.	Ability to independently carry out research/investigation and development work to solve practical problems
2.	Ability to write and present a substantial technical report/document
3.	Able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery shall be at a level higher than the requirements in the appropriate bachelor programme.
4.	Ability to use scientific knowledge and analytical skills to successfully discover, analyze, and solve complex environmental problems.
5.	Able to collaborate effectively with diverse teams to develop innovative solutions to complex environmental problems, demonstrating leadership and effective communication skills.
6.	Ability to develop and assess sustainable technologies and systems that address environmental concerns while taking economic, social, and environmental factors into account.

3. PEO/PO Mapping:

Program Educational Objectives	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
i.	**3**	**2**	**3**	**3**	**2**	**2**
ii.	**3**	**2**	**3**	**3**	**2**	**3**
iii.	**3**	**2**	**3**	**3**	**2**	**2**
iv.	**3**	**2**	**3**	**3**	**2**	**2**
v.	**3**	**2**	**3**	**3**	**2**	**2**

4. PROGRAM ARTICULATION MATRIX

Year	Semester	Course name	PO					
			1	2	3	4	5	6
I	I	Advanced Numerical Methods	3	3	3	3	2	2
		Research Methodology and IPR						
		Unit Operations and Unit Processes in Environmental Technology	3	3	3	2	1.6	1
		Biological Wastewater Treatment	2	2	1.8	2	1.8	1.6
		Air and Noise Pollution Control Engineering	3	2.8	3	2	3	2.4
		Environmental Monitoring and Analysis	2.7	1.5	1.8	2.8	1	1.8
		Program Elective I						
	II	Environmental Impact Assessment	1.67	2.2	3	2.5	3	1.75
		Solid and Hazardous Waste Management	2.5	3	2.75	2	2	2.2
		Environmental Policies and Legislation	1	1	-	3	3	3
		Separation Processes in Environmental Applications	2.5	1.7	2.2	2.5	1.6	1.1
		Program Elective II						
		Program Elective III						
		Environmental Engineering Lab II	2.25	2.5	3	3	2.75	3
		Mini Project with Seminar	2.6	2.6	3	2.3	3	2
II	III	Modeling of Environmental systems	2.6	2	2	3	1.6	2
		Industrial Pollution Prevention Strategies	1	1.2	1	1.2	-	1
		Program Elective IV						
		Program Elective V						
		Project Work I	2.75	2.5	2.25	1.75	1.75	2
	IV	Project Work II	3	2.33	2	2	1.67	2
			2.75	2.5	2.25	1.75	1.75	2

ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
M. TECH. ENVIRONMENTAL SCIENCE AND TECHNOLOGY
REGULATIONS – 2023
CHOICE BASED CREDIT SYSTEM
CURRICULUM AND SYLLABI FOR I TO IV SEMESTERS

SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1	MA3155	Advanced Numerical Methods	FC	4	0	0	4	4
2	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
3	EV3101	Unit Operations and Unit Processes in Environmental Technology	PCC	3	0	0	3	3
4	EV3102	Biological Wastewater Treatment	PCC	3	0	0	3	3
5	EV3103	Air and Noise Pollution Control	PCC	3	0	0	3	3
6	EV3104	Environmental Monitoring and Analysis	PCC	2	0	2	4	3
7		Professional Elective I	PEC	3	0	0	3	3
			TOTAL	**20**	**1**	**2**	**23**	**22**

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	EV3201	Separation Processes in Environmental applications (Laboratory Integrated Course)	PCC	2	0	2	4	3
2.	EV3202	Environmental Impact Assessment	PCC	3	0	0	3	3
3.	EV3203	Solid and Hazardous Waste Management	PCC	3	0	0	3	3
4.	EV3204	Environmental Policies and Legislation	PCC	3	0	0	3	3
5.		Professional Elective II	PEC	3	0	0	3	3
6.		Professional Elective III	PEC	3	0	0	3	3
PRACTICALS								
7.	EV3211	Environmental Engineering Lab II	PCC	0	0	4	4	2
8.	EV3212	Mini Project with Seminar	EEC	0	0	2	2	1
			TOTAL	**14**	**0**	**8**	**25**	**21**

SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	EV3301	Modeling of Environmental Systems	PCC	3	1	0	4	4
2.	EV3302	Industrial Pollution Prevention Strategies	PCC	3	0	0	3	3
3.		Professional Elective IV	PEC	3	0	0	3	3
4.		Professional Elective V	PEC	3	0	0	3	3
PRACTICALS								
5.	EV3311	Project Work I	EEC	0	0	12	12	6
			TOTAL	**12**	**1**	**12**	**25**	**19**

SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	EV3411	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS: 74

FUNDAMENTAL COURSES

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS	SEMESTER
				L	T	P			
1.	MA3155	Advanced Numerical Methods	FC	4	0	0	4	4	1

LIST OF PROFESSIONAL CORE COURSES (PCC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	EV3101	Unit Operations and Unit Processes in Environmental Technology	3	0	0	3	1
2.	EV3102	Biological Waste Water Treatment	3	0	0	3	1
3.	EV3103	Air and Noise Pollution Control Engineering	3	0	0	3	1
4.	EV3104	Environmental Monitoring Analysis	2	0	2	3	1
5.	EV3202	Environmental Impact Assessment	3	0	0	3	2
6.	EV3203	Solid and Hazardous Waste Management	3	0	0	3	2

7.	EV3204	Environmental Policies and Legislation	3	0	0	3	2
8.	EV3201	Separation Processes in Environmental Applications (Laboratory Integrated	2	0	2	3	2
9.	EV3211	Environmental Engineering Lab II	0	0	4	2	2
10.	EV3302	Industrial Pollution Prevention Strategies	3	0	0	3	3
11.	EV3301	Modeling of Environmental Systems	3	1	0	4	3
TOTAL CREDITS						**33**	

PROFESSIONAL ELECTIVE COURSES

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	EV3001	Ecology and Environment	PEC	3	0	0	3	3
2.	EV3002	Environmental Risk Assessment	PEC	3	0	0	3	3
3.	EV3003	Risk Analysis and Hazop	PEC	3	0	0	3	3
4.	EV3004	Environmental Nanotechnology	PEC	3	0	0	3	3
5.	CL3055	Sustainable Management	PEC	3	0	0	3	3
6.	CL3052	Design of Experiments	PEC	2	0	2	4	3
7.	EV3005	Green Chemistry and Engineering	PEC	3	0	0	3	3
8.	EV3006	Environmental Sustainability	PEC	3	0	0	3	3
9.	EV3007	Principles of Cleaner Production	PEC	3	0	0	3	3
10.	EV3008	Advanced Oxidation Processes and Technology	PEC	3	0	0	3	3
11.	EV3051	Electrochemical Environmental Technology	PEC	3	0	0	3	3
12.	CL3054	Industrial Instrumentation	PEC	3	0	0	3	3
13.	EV3009	Remote Sensing and GIS Applications in Environmental Management	PEC	3	0	0	3	3
14.	EV3010	Soil Remediation Technologies	PEC	3	0	0	3	3
15.	EV3011	Environmental Health and Safety in Industries	PEC	3	0	0	3	3
16.	EV3012	Environmental Management	PEC	3	0	0	3	3
17.	EV3013	Environmental Biotechnology	PEC	3	0	0	3	3
18.	EV3014	Waste Management and Energy recovery	PEC	3	0	0	3	3

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1	RM3151	Research Methodology and IPR	3	0	0	3	1
					TOTAL CREDITS	3	

LIST OF EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	EV3212	Mini Project with Seminar	0	0	2	1	2
2.	EV3311	Project Work I	0	0	12	6	3
3.	EV3411	Project Work II	0	0	24	12	4
					TOTAL CREDITS	19	

SUMMARY

	Name of the Programme: M.Tech Environmental Science And Technology					
	SUBJECT AREA	CREDITS PER SEMESTER				CREDITS TOTAL
		I	II	III	IV	
1.	FC	4	0	0	0	4
2.	PCC	16	8	4	0	33
3.	PEC	3	6	6	0	15
4.	RMC	3	0	0	0	3
5.	EEC	0	1	6	12	19
6.					TOTAL CREDIT	74

MA3155 ADVANCED NUMERICAL METHODS L T P C
4 0 0 4

OBJECTIVES

- To make the students understand the methods/algorithms to numerically solve a system of simultaneous algebraic equations.
- To make the students understand the methods to numerically solve the system of simultaneous ordinary differential equations.
- To make the students understand the methods to numerically solve the partial differential equations.
- To make the students understand the methods to numerically solve the elliptic equations.
- To make the students understand the finite element methods for solving the PDEs.

UNIT I ALGEBRAIC EQUATIONS 12

Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm for tridiagonal system – Jacobi, Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Method, Eigenvalue problems: power method, Faddeev – Leverrier Method.

UNIT II ORDINARY DIFFERENTIAL EQUATIONS 12

Runge Kutta Methods for system of IVPs, numerical stability, Adams-Bashforth multistep method, solution of stiff ODEs, shooting method, BVP: Finite difference method, collocation method, orthogonal collocation method, Galerkin finite element method

UNIT III FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATION 12

Parabolic equations: explicit and implicit finite difference methods, weighted average approximation - Dirichlet and Neumann conditions – Two dimensional parabolic equations – ADI method; First order hyperbolic equations – method of characteristics, Lax-Wendroff explicit and implicit methods; numerical stability analysis, method of lines – Wave equation: Explicit scheme- Stability of above schemes

UNIT IV FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS 12

Laplace and Poisson's equations in a rectangular region: Five point finite difference schemes, Leibmann's iterative methods, Dirichlet and Neumann conditions – Laplace equation in polar coordinates: finite difference schemes – approximation of derivatives near a curved boundary while using a square mesh.

UNIT V FINITE ELEMENT METHOD 12

Partial differential equations – Finite element method - collocation method, orthogonal collocation method, Galerkin finite element method.

TOTAL: 60 PERIODS

OUTCOMES:

At the end of the course, students will be able to

CO1 Solve numerically system of simultaneous algebraic equations.
CO2 Solve the simultaneous ordinary differential equations (IVP) numerically.
CO3 Solve numerically set of Partial differential equations.
CO4 Solve the set of Elliptic equations numerically.
CO5 Solve the set of PDEs by finite element method.

REFERENCES:

1. Burden. R. L. and Faires. J. D., "Numerical Analysis; Theory and Applications", India Edition, Cengage Learning, 2010.
2. Jain M.K., Iyengar S.R.K. and Jain R.K., Computational Methods for Partial Differential Equations, New Age International, 2nd Edition, New Delhi, 2016.

3. Morton K.W., and Mayers D.F., “Numerical Solution of Partial Differential Equations, Cambridge University Press, Second Edition, Cambridge, 2005.
4. Santosh K Gupta, “Numerical Methods for Engineers”, New Age International (P) Limited, Publishers, New Delhi, 2014.
5. Sastry S.S., "Introductory Methods of Numerical Analysis", Prentice - Hall of India Pvt. Limited, 5th Edition, New Delhi, 2012.
6. Saumyen Guha and Rajesh Srivastava, “Numerical methods for Engineering and Science”, Oxford Higher Education, New Delhi, 2010.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg	**3**	**3**	**3**	**3**	**2**	**2**

RM3151 RESEARCH METHODOLOGY AND IPR L T P C
2 1 0 3

OBJECTIVES:

To impart knowledge on

- Formulation of research problems, design of experiment, collection of data, interpretation and presentation of result
- Intellectual property rights, patenting and licensing

UNIT I RESEARCH PROBLEM FORMULATION 9

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis-concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR

practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, the student can

CO1: Describe different types of research; identify, review and define the research problem

CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data

CO3: Explain the process of data analysis; interpret and present the result in suitable form

CO4: Explain about Intellectual property rights, types and procedures

CO5: Execute patent filing and licensing

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
3. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.
5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

EV3101 UNIT PROCESS AND UNIT OPERATIONS IN ENVIRONMENTAL TECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES

- 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

UNIT I OVERVIEW PROCESS SELECTION 9

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

UNIT II MIXING -COAGULATION 9

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

UNIT III FILTRATION 9

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

UNIT IV CHEMICAL PRECIPITATION 9

Chemical precipitation - phosphate removal - Adsorption - Activated carbon - Isotherms – Disinfection – Factors Influencing - Breakpoint chlorination – De chlorination.

UNIT V AEROBIC AND ANAEROBIC PROCESS 9

Kinetics of Biological growth - Suspended and attached growth processes - Aerobic and Anaerobic - Determination of kinetic coefficients.

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1 Review the fundamentals of unit operation involve in Environmental process

CO2 Recognise and recall the basics of Coagulation and Flocculation, Reactor types, Sedimentation - settling - Clarifier- flotation

CO3 Discuss the concept of filtration and its application

CO4 Apply the concept of Adsorption - Isotherms, chlorination

CO5 Analysis of suspended and attached growth processes aerobic and anaerobic – processes

REFERENCE BOOKS

1. Reynold D and Richards A, " Unit Operations and Processes in Environmental Engineering" 2nd Edition, PWS Publication, 1996
2. Theodore L, Ryan Dupont R and Ganesan K, " Unit Operations in Environmental Engineering", Wiley Publication 2017.
3. Mc cabe.W, Smith J," Unit operations of chemical engineering, McGraw-Hill Publication,2005
4. Geankoplis, J,C, "Transport Processes and Separation Process Principles" 4th edition, Pearson publication , 2015
5. Metcalf & Eddy, INC, Wastewater Engineering – Treatment and Reuse, Fourth Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2003..

COURSE ARTICULATE MATRIX:

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

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

EV3102 BIOLOGICAL WASTEWATER TREATMENT L T P C
3 0 0 3

OBJECTIVES

- 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.

UNIT I FUNDAMENTAL OF BIOCHEMICAL OPERATIONS 9

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:

UNIT II AEROBIC/ANEROBIC PROCESS AND SLUDGE MANAGEMENT 9

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.

UNIT III SUSPENDED GROWTH REACTORS 9

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.

UNIT IV ATTACHED GROWTH REACTORS 9

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

UNIT V INDUSTRIAL APPLICATION CASE STUDIES 9

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.,

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1 Review the concepts and fundamentals of biochemical operations used in wastewater treatment

CO2 Discuss the basics of aerobic and anaerobic process in the sludge management

CO3 Classify the types and applications of suspended growth reactors used in wastewater treatment

CO4 Analyse the mechanism and operations of attached growth reactors used in wastewater treatment

CO5 Apply types and applications of reactors used in wastewater treatment and case studies

REFERENCE BOOKS

1. Grady, C.P.L, Daigger, G. T. and Lim, H.C, Biological Wastewater Treatment, 2nd Ed, Marcel Dekker, 1999
2. Mizrahi A, Biological Waste Treatment, John Wiley Sons Inc 1989.

3. Patwardhan A.D. Industrial Wastewater Treatment, Prentice Hall of India Ltd, New Delhi, 2008.
4. Metcalf & Eddy, INC, Wastewater Engineering – Treatment and Reuse, Fourth Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2003.
5. David Hendricks, Fundamentals of Water Treatment Process, CRC Press, New York 2011
6. Spellman, F.R., Hand Book of Water and Wastewater Treatment Plant operations, CRC Press, New York 2009

COURSE ARTICULATE MATRIX:

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

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

EV3103 AIR AND NOISE POLLUTION CONTROL ENGINEERING L T P C
3 0 0 3

OBJECTIVES

- 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

UNIT I INTRODUCTION TO AIR QUALITY 9

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.

UNIT II INDUSTRIAL AIR POLLUTION SOURCES AND PREVENTION 9

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

UNIT III VENTILATION AND INDOOR AIR QUALITY CONTROL 9

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

UNIT IV PREVENTION VERSUS CONTROL 9

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

UNIT V NOISE POLLUTION 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1 Discuss the nature and characteristics of air pollutants, noise pollution and basic concepts of air quality management.

CO2 Identify, formulate and solve air and noise pollution problems

CO3 Design stacks and particulate air pollution control devices to meet applicable standards

CO4 Report the indoor air quality behaviour and its measurements

CO5 Analyse the air pollution using various devices, environmental health effects using air and noise pollution and cost accounting.

REFERENCE BOOKS

1. Lawrence K. Wang, Norman C. Parelra, Yung Tse Hung, Advanced air and Noise Pollution Control Engineering, Volume 2, 2005.
2. Noel de Nevers, Air Pollution Control Engineering, McGraw Hill, New York, 2011.
3. David H.F. Liu, Bela G. Liptak 'Air Pollution', Lweis Publishers, 2000.
4. Anjaneyulu. Y, 'Air Pollution and Control Technologies', Allied Publishers (P) Ltd., India, 2002.
5. Arthur C.Stern, 'Air Pollution (Vol.I–Vol.VIII)', Academic Press, 2006.
6. Wayne T.Davis, 'Air Pollution Engineering Manual', John Wiley & Sons, Inc., 2000.
7. Nikhil Sharma, Avinash Kumar Akhilendra P Singh, Air pollution control, springer nature 2018.

COURSE ARTICULATE MATRIX:

Course Outcomes	PROGRAM OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	3	2
CO2	3	3	3	2	3	2
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
CO5	3	2	3	3	3	2
AVERAGE CO	**3**	**2.8**	**3**	**2**	**3**	**2.4**

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

EV3104 ENVIRONMENTAL MONITORING AND ANALYSIS L T P C
2 0 2 3

OBJECTIVES

- 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.

UNIT I ANALYSIS OF ENVIRONMENTAL PARAMETERS 6

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

UNIT II WATER QUALITY ASSESSMENT AND MANAGEMENT 6

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

UNIT III AIR POLLUTION ANALYSIS AND CONTROL 6

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.

UNIT IV MANAGEMENT OF SOLID WASTE 6

Composition of solid waste. Characterization techniques. Domestic and industrial solid waste.

UNIT V ENVIRONMENTAL DISASTERS AND REGULATIONS 6

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

THEORY: 30 PERIODS

List of laboratory experiments:

PRACTICAL: 30 PERIODS

1. Determination of Acidity and Alkalinity, Chlorides in liquid samples
2. Dissolved and undissolved solids and settleable solids, determination in wastewater
3. Soil/sediment analysis: moisture & pH determination, organic content.
4. Air quality analysis.
5. Sampling and analysis of organic contaminants in soil samples
6. Measurement of turbidity and Jar test

TOTAL: 60 PERIODS

COURSE OUTCOMES

THEORY:

CO1 Recognize and recall the environmental compartments and their interactions.
CO2 Identify and explain the monitoring parameters used in water and air analysis.
CO3 Analyse the composition of various types of solid samples.
CO4 Describe the environmental laws and regulatory standards relevant to environmental monitoring and analysis.
CO5 Apply practical techniques for sampling and measurement of relevant parameters in environmental samples.

CO6 Perform accurate analysis of various parameters in environmental samples, such as acidity, alkalinity, chlorides, solids, turbidity, moisture, pH, and organic content.
CO7 Demonstrate proficiency in sampling techniques and instrumentation for detecting and analysing organic contaminants in environmental samples.
CO8 Conduct air quality analysis using appropriate equipment and methods to assess and monitor ambient air quality.

REFERENCE BOOKS

1. Thibodeaux, L. J., "Environmental chemodynamics: Movement of chemicals in air, water, and soil", 2nd Ed, John Wiley & Sons, 1996.
2. Peavy, H. S., Rowe, D. R., & Tchobanoglous, G., "Environmental engineering", New York: McGraw-Hill, 1985.
3. Stanley E Manahan., "Environmental Chemistry", 8th Edition, CRC Press, 2004
4. Seinfeld, J.H. and Pandis, S.N. Atmospheric Chemistry and Physics: From Air Pollution to Climate Change. John Wiley & Sons, Hoboken, 2016.
5. Thibodeaux, L. J., & Mackay, D. (Eds.), "Handbook of chemical mass transport in the environment", CRC Press, 2010.

COURSE ARTICULATION MATRIX:

Course Outcomes	PROGRAM OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	1	-	1	3
CO2	3	1	2	2	-	2
CO3	1	1	1	2	1	1
CO4	3	1	2	3	1	2
CO5	3	1	2	3	1	2
CO6	3	2	2	3	-	2
CO7	3	2	2	3	1	1
CO8	3	2	2	3	-	1
Average CO	**2.7**	**1.5**	**1.8**	**2.8**	**1**	**1.8**

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

EV3201 SEPARATION PROCESSES IN ENVIRONMENTAL APPLICATIONS L T P C
2 0 2 3

OBJECTIVES

- To enable students to learn the fundamentals of separation processes.
- To enable students tounderstand 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

UNIT I DISTILLATION & EXTRACTION 6

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

UNIT II ABSORPTION AND ADSORPTION 6

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

UNIT III DRYING & FILTRATION 6

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

UNIT IV ION-EXCHANGE 6

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

UNIT V MEMBRANE PROCESSES 6

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

List of Laboratory Equipment 30 PERIODS

1. Batch distillation
2. Liquid-liquid Extraction
3. Cross current Leaching
4. Gas – Liquid Absorption
5. Adsorption studies
6. Separation using Ion-Exchange column
7. Vacuum Filtration
8. Dryer.

TOTAL: 60 PERIODS

COURSE OUTCOMES

THEORY

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 Ion exchange mechanism and design the system for environmental application

CO5 Recognize the basic principle, different types of membrane, membrane modules and various membrane process and its mechanisms.

CO6 Analyse and asses the efficiency of distillation and extraction process

CO7 Demonstrate the various gas- liquid separation and fluid solid separation techniques

CO8 Illustrate the concept behind drying and filtration.

REFERENCE BOOKS

1. Noble, R.D and Terry P.A., Principles of Chemical Separations with Environmental Applications, Cambridge University Press, 2004.
2. Seader J D and Henley E J, Separation Processes Principles, 3rd Edition, John Wiley & 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.

EV3202 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

UNIT I COMPONENTS AND TYPES 9

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

UNIT II IMPACT PREDICTION AND ANALYSIS 9

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.

UNIT III TRENDS AND DEVELOPMENTS IN EIA 9

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

UNIT IV REPORT WRITING AND POST EIA 9

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.

UNIT V CASE STUDIES 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1 Recall and recognize environmental impact and environmental risk assessments and related legal procedures.
CO2 Classify various components and assessment techniques related to EIA.
CO3 Analyze the trends, mistakes and importance of capacity building in EIA.
CO4 Explain about document planning and environmental monitoring in EIA
CO5 Assess the knowledge on EIA by studying related case studies

REFERENCE BOOKS

1. Canter, L.W., Environmental Impact Assessment, McGraw Hill, New York, 1996.
2. Petts, J., Handbook of Environmental Impact Assessment Vol. I and II, Blackwell Science, London, 2009.
3. The World Bank Group, Environmental Assessment Sourcebook Vol. I, II and III, The World Bank, Washington, 1991.
4. Lawrence, D.P., Environmental Impact Assessment – Practical solutions to recurrent problems, Wiley-Inter science, New Jersey, 2003
5. Marriott B., "Environmental Impact Assessment: A Practical Guide",McGraw-Hill Publication,1997
6. Wathern P., "Environmental Impact Assessment: Theory and Practice",Routledge Publishers,1990
7. EIA Notification 2006, India

COURSE ARTICULATE MATRIX:

Course Outcomes	PROGRAM OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	2	3	-	-	1
CO2	2	2	3	2	-	3
CO3	-	1	3	-	-	1
CO4	1	3	3	-	3	-
CO5	2	3	3	3	3	2
AVERAGE CO	**1.67**	**2.2**	**3**	**2.5**	**3**	**1.75**

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

EV3203 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

UNIT I INTRODUCTION TO SOLID WASTE MANAGEMENT 9

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 II UNIT OPERATIONS INVOLVED IN ENERGY RECOVERY FROM WASTE9

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

UNIT III HANDLING AND STORAGE OF HAZARDOUS WASTE 9

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

UNIT IV DISPOSAL OF HAZARDOUS WASTES 9

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.

UNIT V SAMPLING OF WASTES 9

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

TOTAL: 45 PERIODS

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.

EV3204 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

UNIT I INTRODUCTION 9

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).

UNIT II WATER (P&CP) ACT, 1974 9

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.

UNIT III AIR (P&CP) ACT, 1981 9

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.

UNIT IV ENVIRONMENT (PROTECTION) ACT 1986 9

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.

UNIT V LEGAL FRAMEWORK AND STRATEGIES FOR WASTE MANAGEMENT9

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.

TOTAL: 45 PERIODS

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.

REFERENCE BOOKS

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.

EV3211 ENVIORNMENTAL 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

Sl.No

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 BOOKSS

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.

EV3212 MINI PROJECT WITH SEMINAR LT P C
0 0 2 1

OBJECTIVES

- To enable the students, get exposure to the recent developments in the field of Environmental engineering,
- To enable the students to conduct literature review and to demonstrate the studies
- To enable the students achive knowledge on writing and presentation skills

TOTAL: 30 PERIODS

COURSE CONTENT:
The students will select a topic related to the field of interest, select literature related to latest developments, analyse, prepare the report and present before the committee for assessment as per Regulations of University

COURSE OUTCOMES
CO1 Report the latest improvements in their field of expertise
CO2 Review the significant works of literature for the selected and suitable topic
CO3 Practice the presentation and communication skills

COURSE ARTICULATE MATRIX:

Course Outcomes	PROGRAM OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	3	2
CO2	2	3	3	2	3	2
CO3	3	2	3	3	3	2
AVERAGE CO	**2.6**	**2.6**	**3**	**2.3**	**3**	**2**

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

SEMESTER III

EV3301 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

UNIT I MODELLING OF ENVIRONMENTAL SYSTEMS 12
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

UNIT II MODELLING APPROACHES 12
Mechanistic modelling, Data driven approaches- Neural Network, Fuzzy System Modeling for environmental systems; Future Directions in Environmental Modeling

UNIT III HYDROLOGICAL SYSTEM 12
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

UNIT IV MICROBIAL SYSTEM 12

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

UNIT V ECO SYSTEM MODELING 12

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

TOTAL: 60 PERIODS

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

REFERENCE BOOKS

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.
7.

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.

EV3302 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

UNIT I INDUSTRIAL POLLUTION 9

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.

UNIT II POLLUTION PREVENTION 9

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.

UNIT III POLLUTION CONTROL STRATEGIES 9

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.

UNIT IV AIR POLLUTION CONTROL ACTS & RULES 9

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.

UNIT V WATER POLLUTION CONTROL ACTS & RULES 9

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

TOTAL: 45 PERIODS

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.

EV3311 **PROJECT WORK I** **L T P C**
0 0 12 6

OBJECTIVES:

The course aims to enable the students to identify the research problem relevant to their field of interest, search databases to define the problem, design experiment, conduct preliminary study and report the findings.

COURSE CONTENT

Individual students will identify a research problem relevant to his/her field of study with the approval of project review committee. The student will collect, and analyze the literature and design the experiment. The student will carry out preliminary study, collect data, interpret the result, prepare the project report and present before the committee.

TOTAL: 180 PERIODS

OUTCOMES:

At the end of the course the students will be able to
CO1: Identify the research problem
CO2: Collect, analyze the relevant literature and finalize the research problem
CO3: Design the experiment, conduct preliminary experiment, analyse the data and conclude
CO4: Prepare project report and present

COURSE ARTICULATION MATRIX:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	2	1	1	2
CO2	3	3	2	2	2	2
CO3	3	2	2	3	2	2
CO4	2	3	3	1	2	2
Average CO	**2.75**	**2.5**	**2.25**	**1.75**	**1.75**	**2**

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

SEMESTER IV

EV3411 PROJECT WORK II

L	T	P	C
0	0	24	12

I. Continuation of Project Work I (at Institution/Industry)

OBJECTIVES:
The course aims to enable the students to conduct experiment as per the plan submitted in Project work I to find solution for the research problem identified.

COURSE CONTENT
The student shall continue Project work I as per the formulated methodology and findings of preliminary study. The student shall conduct experiment, collect data, interpret the result and provide solution for the identified research problem. The student shall prepare the project report and present before the committee.

TOTAL: 360 PERIODS

OUTCOMES:
At the end of the course the students will be able to
CO1: Conduct the experiment and collect data
CO2: Analyze the data, interpret the results and conclude
CO3: Prepare project report and present

Course articulation Matrix

Course articulation Matrix

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	2	1	1	2
CO2	3	3	2	2	2	2
CO3	3	2	2	3	2	2
Average CO	3	2.33	2	2	1.67	2

II. Not the continuation of Project Work I (at Industry)

OBJECTIVES:
The course aims to enable the students to identify the research problem at the company, search databases to define the problem, design experiment, and conduct experiment to find the solution.

COURSE CONTENT
Individual students will identify a research problem relevant to his/her field of study at the company and get approval of project review committee. The student will collect, and analyze the literature and design the experiment. The student will carry out the experiment, collect data, interpret the result, prepare the project report and present before the committee.

TOTAL: 360 PERIODS

OUTCOMES:
At the end of the course the students will be able to
CO1: Identify the research problem
CO2: Collect, analyze the relevant literature and finalize the research problem

CO3: Design and conduct the experiment, analyse the data and conclude
CO4: Prepare project report and present

COURSE ARTICULATION MATRIX:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	2	1	1	2
CO2	3	3	2	2	2	2
CO3	3	2	2	3	2	2
CO4	2	3	3	1	2	2
Average CO	2.75	2.5	2.25	1.75	1.75	2

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

EV3001 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.

UNIT I INTRODUCTION TO ECOLOGY AND ECOSYSTEMS 9

Introduction 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.

UNIT II ECOTECHNOLOGY AND HUMAN INTERACTIONS 9

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.

UNIT III ECOLOGICAL ENGINEERING 9

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.

UNIT IV WASTE MANAGEMENT IN ECOSYSTEMS 9

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.

UNIT V SOCIETY TO ECOSYSTEM 9

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.

TOTAL: 45 PERIODS

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

REFERENCE BOOKS

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

EV3002 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

UNIT I RISK ASSESSMENT BACKGROUND 9

Introduction to environmental risk assessment and available methodologies; Types of risks; quantitative risk assessment; Risk assessment steps; rapid risk analysis; comprehensive risk analysis.

UNIT II STAGES OF ENVIRONMENTAL RISK ASSESSMENT 9

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

UNIT III STANDARDS AND POLICIES 9

Overall risk contours for different failure scenarios; disaster management plan; emergency planning; risk management ISO 14000; government policies to manage environmental risk.

UNIT IV MODELLING 9

Safety measures design in process operations; Accidents modeling – release modeling, toxicrelease and dispersion modeling, fire and explosion modeling, EMS models.

UNIT V HEALTH RISK ASSESSMENT AND CASE STUDIES 9

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

TOTAL: 45 PERIODS

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 andApply knowledge obtained for reducing the risk in workplace

REFERENCE BOOKS

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

COURSEARTICULATIONMATRIX:

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

EV3003 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

UNIT I INTRODUCTION TO RISK ANALYSIS 9

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.

UNIT II RADIATION AND COMMUNICATION 9

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.

UNITIII RISK ANALYSIS AND MANAGEMENT 9

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

UNIT IV SAFETY AUDITS 9

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.

UNIT V HAZOP STUDY 9

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

TOTAL: 45 PERIODS

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

REFERENCE BOOKS

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	PROGRAM OUTCOMES					
	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

EV3004 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

UNIT I INTRODUCTION TO ENVIRONMENTAL NANOTECHNOLOGY 9

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

UNIT II NANOMATERIAL SYNTHESIS 9

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.

UNIT III NANOPARTICLES IN WASTEWATER TREATMENT 9

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

UNIT IV APPLICATIONS IN WASTE MANAGEMENT 9

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

UNIT V NANOPARTICLES: HEALTH AND ENVIRONMENTAL RISK 9

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.

TOTAL: 45 PERIODS

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.

.

REFERENCE BOOKS

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

CL3055	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.

UNIT I INTRODUCTION TO SUSTAINABLE MANAGEMENT 9

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

UNIT II SUSTAINABLE PROCESS DESIGN AND OPTIMIZATION 9

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

UNIT III ENERGY EFFICIENCY AND CONSERVATION 9

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.

UNIT IV WASTE MINIMIZATION AND RESOURCE RECOVERY 9

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.

UNIT V SUSTAINABLE SUPPLY CHAIN MANAGEMENT IN INDUSTRY 9

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.

TOTAL: 45 PERIODS

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.

REFERENCE BOOKS

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	PROGRAM OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	1	1	1
CO2	1	2	2	3	3	2
CO3	2	3	3	3	3	2
CO4	2	2	1	3	1	1
CO5	1	2	2	2	3	2
AVERTAGE 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

CL3052 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.

UNIT I FOUNDATIONS OF PROBABILITY AND STATISTICS FOR ENGINEERS6

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.

UNIT II PRINCIPLES OF EXPERIMENTAL DESIGN 6

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.

UNIT III REGRESSION MODELING AND ANALYSIS 6

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

UNIT IV ANALYSIS OF VARIANCE AND EXPERIMENTAL INFERENCE 6

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.

UNIT V ADVANCED TOPICS IN STATISTICS AND EXPERIMENTAL DESIGN 6

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.

THEORY 30 PERIODS

List of tasks to be performed by students: Software Minitab/equivalent alternative

PRACTICAL: 30 PERIODS

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.

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1 Discuss foundational probability and statistics concepts and apply them to solve engineering problems.

CO2 Apply statistical inference techniques to draw conclusions from experimental data.

CO3 Demonstrate proficiency in the analysis of variance (ANOVA) technique and apply it to experimental design and interpretation of results.

CO4 Develop 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..

CO6: Recall and apply foundational statistical concepts in practical data analysis using software tools like Minitab.

CO7: Demonstrate proficiency in conducting hypothesis tests, constructing confidence intervals, and analyzing experimental data using software.

CO8: Analyze regression models, interpret their coefficients, and evaluate model adequacy through diagnostic plots and statistical tests using software.

REFERENCE BOOKS

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	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	1	1	1
CO2	1	3	1	1	3	1
CO3	1	1	3	1	1	1
CO4	2	1	3	1	1	1
CO5	1	1	1	1	3	1
CO6	1	1	2	2	3	2
CO7	3	2	2	2	3	2
CO8	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

EV3005 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

UNIT I INTRODUCTION TO GREEN CHEMISTRY 9

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

UNIT II ENVIRONMENTAL ISSUES AND RISK ASSESSMENT 9

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.

UNIT III POLLUTION PREVENTION AND PROPERTY ESTIMATION 9

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

UNIT IV EVALUATING EXPOSURES 9

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.

UNIT V FLOW SHEET ANALYSIS AND LIFE CYCLE ASSESSMENT 9

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

TOTAL: 45 PERIODS

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

REFERENCE BOOKS

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:

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

EV3006 ENVIRONMENTAL SUSTAINABILITY L T P C
3 0 0 3

OBJECTIVES

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**

- 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.

UNIT I VALUING THE ENVIRONMENT 9

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

UNIT II SUSTAINABLE DEVELOPMENT 9

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

UNIT III AIR POLLUTION 9

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

UNIT IV WATER POLLUTION 9

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

UNIT V VISIONS OF FUTURE 9

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

TOTAL: 45 PERIODS

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.

REFERENCE BOOKS

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

EV3007 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

UNIT I INTRODUCTION 9

Sustainable Development – Indicators Of Sustainability – Sustainability Strategies – Barriers To Sustainability–Industrial Activities And Environment– Industrialization And Sustainable Development–Industrial Ecology–Cleaner Production(CP)in Achieving Sustainability Prevention 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.

UNIT II CLEANER PRODUCTION 9

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

UNIT III QUALITATIVE PHASE BEHAVIOUR OF HYDROCLEANER PRODUCTION PROJECT DEVELOPMENT & IMPLEMENTATION 9

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 Program Plan–Measuring Progress–Pollution Prevention And Cleaner Production Awareness Plan.

UNIT IV SUPPORT INSTURMENTS OF PREVENTION METHODS 9

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.

UNIT V CASE STUDIES 9

Industrial Applications Of CP, LCA,EMS And Environmental Audits.

TOTAL: 45 PERIODS

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.

COURSEARTICULATIONMATRIX:

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

EV3008 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 studentsto learn the various types of AOP and their mechanism
- To enable studentsto learn the heterogeneous AOP and its applications
- To enable studentsto understand the various characterization techniques in AOP

UNIT I OVERVIEW OF AOP **9**

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

UNIT II TYPES OF AOP AND ITS MECHANISM **9**

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

UNIT III PHOTO BASED AOP PROCESSES **9**

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

UNIT IV HETEROGENOUS AOP **9**

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

UNIT V APPLICATION AND CHARACTERIZATION 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1 Review the fundamentals of AOP.
CO2 Classify the types of AOP and its 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, Reaction Mechanisms, Reactor Concepts”, Wiley-VCH Publishing, Published by, 2003.
3. Harold J.Ratson, “Odor and VOC Control Handbook”, Newyork, Mcgraw-hill, 1998.
4. Vincenzo Belgiorno, Vincenzo Naddeo and Luigi Rizzo, “Water, Wastewater and Soil treatment by Advanced Oxidation Processes (AOP)”, Lulu Enterprises, 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.

EV3051 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

UNIT I ELETROCHEMISTRY 9

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

UNIT II ELECTROCHEMICAL PROCESS AND ITS IMPORTANCE 9

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.

UNIT III PHOTOELECTROCHEMICAL REACTOR 9

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

UNIT IV TYPES OF ELECTROCHEMICAL REACTOR 9

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.

UNIT V HYBRID ELECTROCHEMICAL REACTOR 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1 Report the physical and chemical characteristics of wastewater and their measurement

CO2 Discuss basic electrochemical engineering concept to treat the industrial pollutants

CO3 Compare various photo electrochemical 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. and Ibanez, J.G., “Environmental Electrochemistry”, Academic Pre, 1997.
4. Pletcher, D., and Walsh, F., “Industrial Electrochemistry”, 2 Edition Chapman and Hall, 1990.
5. Keith B.Oldham, Jan C Myland,” Electrochemical Science and Technology, Fundamentals and applicaton”, 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.

CL3054 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.

UNIT I INTRODUCTION 9

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.

UNIT II MEASURING INSTRUMENTS 9

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.

UNIT III ANALYTICAL INSTRUMENTS 9

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

UNIT IV CONTROLLERS AND SENSORS 9

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.

UNIT V INDUSTRIAL SAFETY AND SPECIFICATIONS 9

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.

TOTAL: 45 PERIODS

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	Program Outcomes					
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO1	3	3	3	1	2	2
CO2	3	3	3	1	2	2
CO3	3	3	3	1	2	2
CO4	3	3	3	1	2	2
CO5	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

EV3009 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.

UNIT I OVERVIEW OF REMOTE SENSING 9

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

UNIT II REMOTE SENSINGTECHNOLOGY 9

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.

UNIT III DATAPROCESSING 9

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.

UNIT IV GEOGRAPHICAL INFORMATION SYSTEM 9

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

UNIT V REMOTE SENSING AND GIS APPLICATIONS 9

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

TOTAL: 45 PERIODS

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 remote sensing 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. and Simonet, Remote sensing of Environment, Addison Wesley Publishing Company, 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

EV3010 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 soilremediation.

UNIT I OVERVIEW OF SOIL REMEDIATION 9

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

UNIT II INORGANIC AND ORGANIC GEOCHEMISTRY 9

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; organicgeochemistry – organic contamination; distribution of NAPLS in Soils – process controlling the distribution of NAPLS in soil, chemical analysis of NAPLS in soils

UNIT III CONTAMINANT FATE AND TRANSPORT IN SOIL 9

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

UNIT IV REMEDIATION TECHNOLOGIES 9

In situ biological treatments –bioventing, enhanced bioremediation land farming natural attenuation phyto remediation; In situ physical/chemical treatments — electro reclamation solidification/stabilization landfill cap and enhancements soil flushing polymer adsorption;

In situthermal treatments - soil vapour extraction, thermally enhanced vitrification

UNIT V EX SITU TREATMENTS 9

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 decontamination thermal desorption plasma arc incineration pyrolysis vitrification

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1 Identify the soil and classify them, the effects of environmental 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

REFERENCE BOOKS

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.

EV3011 ENVIRONMENT HEALTH AND SAFETY IN INDUSTRIES L T P C
3 0 0 3

OBJECTIVES

- To enable the studentsto know the safety acts, regulations and initiatives.
- To enable students toachive 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.

UNIT I OVERVIEW OF ENVIRONMENTAL HEALTH AND SAFETY 9

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.

UNIT II OCCUPATIONAL HEALTH AND HYGIENE 9

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.

UNIT III WORKPLACE SAFETY AND SAFETY SYSTEMS 9

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

UNIT IV TECHNIQUES OF ENVIRONMENTAL SAFETY 9

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.

UNIT V EDUCATION AND TRAINING 9

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.

TOTAL:45 PERIODS

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

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

EV3012 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

UNIT I PRINCIPLES OF ENVIRONMENTAL MANAGEMENT 9

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

UNIT II POLITICAL AND LEGAL ASPECTS OF ENVIRONMENTAL MANAGEMENT 9

Introduction to Environmental policies- Environmental policies and programs in India; environmental law and legislation- environmental legislation in India

UNIT III ENVIRONMENTAL IMPACT ASSESSMENT & AUDITING 9

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

UNIT IV ENVIRONMENTAL MANAGEMENT AND SYSTEM STANDARDS 9

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..

UNIT V ENVIRONMENTAL DESIGN & ECONOMICS 9

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

TOTAL: 45 PERIODS

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

EV3013 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

UNIT I MICROBES AND METABOLISM 9

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

UNIT II DNA TECHNOLOGY 9

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

UNIT III POLLUTION AND POLLUTION CONTROL 9

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.

UNIT IV BIOREMEDIATION 9

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.

UNIT V BIOTECHNOLGY REMEDIES FOR ENVIRONMENTAL DAMAGES 9

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.

TOTAL: 45 PERIODS

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.

REFERENCE BOOKS

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.

EV3014 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

UNIT I WASTE AND WASTE MANAGEMENT LEGISLATION 9

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.

UNIT II WASTE MANAGEMENT 9

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.

UNIT III WASTE TO ENERGY TECHNOLOGIES 9

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..

UNIT IV WASTE TO ENERGY OPTIONS & ENVIRONMENTAL IMPLICATIONS 9

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

UNIT V CASE STUDIES 9

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'

TOTAL: 45 PERIODS

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.

REFERENCE BOOKS

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.