DEPARTMENT OF CHEMICAL ENGINEERING

ANNA UNIVERSITY, CHENNAI - 25

Vision:

Department of Chemical Engineering strives to be a premier institute in India, to create quality chemical engineers who will be highly successful in academic, industries and research. Our research motive is to develop sustainable technologies for the betterment of society.

Mission:

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

ANNA UNIVERSITY:: CHENNAI 600 025

UNIVERSITY DEPARTMENTS

REGULATIONS - 2019

M. TECH. ENVIRONMENTAL SCIENCE AND TECHNOLOGY

CHOICE BASED CREDIT SYSTEM

1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

1. To impart knowledge on modern analytical techniques and computational skills necessary for to design and evaluate complex environmental problems.
2. To impart students with strong knowledge base through theory courses and sessional that makes them suitable for industries, academics, research and consultancies.
3. To develop student's analytical, computational and research skills so as to understand interactions of pollutants in water, air, and subsurface environments, and design treatment/ remediation systems.
4. To educate students to practice environmental engineering with a global perspective and appropriate standards pertaining to health, safety, legal and cultural issues to solutions for complex, engineering problems.
5. To develop in-depth understanding of Environmental technology and developments in the industry through continuous professional developments.
6. Students are expected to Engage in continued learning through professional development.

2. PROGRAMME OUTCOMES (POs)

On successful completion of this programme, the students will have

PO1: An ability to independently carry out research /investigation and development work to solve Practical problems.

PO2: ability to write and present a substantial technical report/document

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO4: Critical thinking skills in relation to environmental affairs and an integrative approach to environmental issues with a focus on sustainability

PO5: Capacity to formulate and solve complex problems associated with environmental Engineering

PO6: Ability to identify the impact of engineering solutions in a global, economic, and Societal context.

PO7: Ability to communicate their thoughts and ideas effectively.

PO8: Interest to acquire knowledge on modern analytical techniques and computational skills necessary for environmental engineers

PO9: The competency in utilizing the available resources effectively and optimally

PO10: The ability to utilize advances in environmental sciences and technology to resolve Environmental issues and anticipate implications

PO11: Inclination towards acquiring knowledge on the latest developments in the field of Environmental engineering

PO12: Ability to use the state of art technology, skills and modern engineering tools necessary for engineering practices

3. MAPPING OF PROGRAMME EDUCATIONAL OBJECTIVE WITH PROGRAMME OUTCOMES

Programme Educational Objectives	Programme Outcomes												Programme Specific Objectives		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1.	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓	✓	✓	✓
2.	✓	✓	✓	✓	✓	-	✓	-	-	-	-	✓	✓	✓	✓
3.	✓	✓	✓	✓	✓	-	-	-	✓	-	-	✓	✓	✓	✓
4.	✓	✓	✓	-	✓	✓	✓	✓	-	-	-	✓	✓	✓	✓
5.	✓	✓	✓	✓	-	✓	✓	✓	-	✓	✓	✓	✓	✓	✓
6.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

4. MAPPING OF COURSE OUTCOMES AND PROGRAMME OUTCOMES

			PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
YEAR I	SEMESTER I	Unit Operations and Unit Processes in Environmental Technology	3	3	3	2	2	1	2	1	1	1	1	3	3	3	3
		Biological Wastewater Treatment	-	-	3	3	3	2	-	1	2	3	3	3	2	3	3
		Air Pollution Control Engineering	3	3	3	3	3	2	3	3	3	2	2	2	2	2	2
		Solid and Hazardous Waste Management	3	2	3	2	3	2	3	3	3	3	2	3	3	3	3
		Program Elective															
		Research Methodology and IPR															
		Audit Course I															
		Environmental Engineering Laboratory –I	3	1	2	3	3	2	3	3	3	2	2	3	3	2	2
		Separation Processes In Environmental Applications Laboratory	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3
	SEMESTER II	Separation Processes in Environmental Applications	3	2	3	3	2	1	1	1	1	1	2	-	3	2	2
		Modeling of Environmental Systems	3	2	2	3	1	2	1	1	1	1	1	1	3	3	3
		Environmental Impact Assessment	-	2	2	3	2	1	1	1	2	2	2	1	1	2	1
		Program Elective															
		Program Elective															
		Audit Course –II															
		Environmental Engineering Laboratory - II	3	1	2	3	3	2	3	3	3	2	2	3	3	2	2
		Advanced Oxidation Process Laboratory	3	3	3	3	2	1	1	1	2	3	2	2	3	3	3
		Mini Project with Seminar	3	3	3	3	3	2	3	3	3	2	2	2	2	2	2

YEAR II	SEMESTER III	Program Elective															
		Program Elective															
		Open Elective															
		Project Phase I	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	SEMESTER IV	Project Phase II	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

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

ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

M. TECH. ENVIRONMENTAL SCIENCE AND TECHNOLOGY

REGULATIONS – 2019

CHOICE BASED CREDIT SYSTEM

CURRICULUM AND SYLLABI FOR I TO IV SEMESTERS

SEMESTER – I

S. NO.	CODE NO.	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	EV5101	Unit Operations and Unit Processes in Environmental Technology	PCC	3	1	0	4	4
2.	EV5102	Biological Wastewater Treatment	PCC	3	0	0	3	3
3.	EV5103	Air Pollution Control Engineering	PCC	3	0	0	3	3
4.	EV5104	Solid and Hazardous Waste Management	PCC	3	0	0	3	3
5.		Program Elective I	PEC	3	0	0	3	3
6.	RM5151	Research Methodology and IPR	RMC	2	0	0	2	2
7.		Audit Course – I*	AC	2	0	0	2	0
PRACTICALS								
8.	EV5111	Environmental Engineering Laboratory-I	PCC	0	0	4	4	2
9.	EV5112	Separation Processes In Environmental Applications Laboratory	PCC	0	0	4	4	2
			TOTAL	**19**	**1**	**8**	**28**	**22**

* Audit Course is Optional

SEMESTER – II

S. NO.	CODE NO.	COURSETITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	EV5201	Separation Processes in Environmental Applications	PCC	3	0	0	3	3
2.	EV5202	Modeling of Environmental Systems	PCC	3	1	0	4	4
3.	EV5203	Environmental Impact Assessment	PCC	3	0	0	3	3
4.		Program Elective II	PEC	3	0	0	3	3
5.		Program Elective III	PEC	3	0	0	3	3
6.		Audit Course –II*	AC	2	0	0	2	0
PRACTICALS								
7.	EV5211	Environmental Engineering Laboratory-II	PCC	0	0	4	4	2
8.	EV5212	Advanced Oxidation Process Laboratory	PCC	0	0	4	4	2
9.	EV5213	Mini Project with Seminar	EEC	0	0	2	2	1
			TOTAL	**17**	**1**	**10**	**28**	**21**

* Audit Course is Optional

SEMESTER III

S. NO.	CODE NO.	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Program Elective IV	PEC	3	0	0	3	3
2.		Program Elective V	PEC	3	0	0	3	3
3.		Open Elective	OEC	3	0	0	3	3
PRACTICALS								
4.	EV5311	Project Phase I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**15**

SEMESTER IV

S. NO.	CODE NO.	COURSETITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	EV5411	Project Phase II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS: 70

PROGRAM CORE COURSES (PCC)

S. No	Code No.	Course Title	Periods Per Week			Credits	Semester
			L	T	P		
1.	EV5101	Unit Operations and Unit Processes in Environmental Technology	3	1	0	4	1
2.	EV5102	Biological Waste Water Treatment	3	0	0	3	1
3.	EV5103	Air Pollution Control Engineering	3	0	0	3	1
4.	EV5104	Solid and Hazardous Waste Management	3	0	0	3	1
5.	EV5111	Environmental Engineering Laboratory-I	0	0	4	2	1
6.	EV5112	Separation Processes In Environmental Applications Laboratory	0	0	4	2	1
7.	EV5201	Separation Processes in Environmental Applications	3	0	0	3	2
8.	EV5202	Modelling of Environmental Systems	3	1	0	4	2
9.	EV5203	Environmental Impact Assessment	3	0	0	3	2
10.	EV5211	Environmental Engineering Laboratory-II	0	0	4	2	2
11.	EV5212	Advanced Oxidation Process Laboratory	0	0	4	2	2

PROFESSIONAL ELECTIVE COURSES (PEC)

S. No	Code No.	Course Title	Periods Per Week			Credits
			L	T	P	
1.	EV5001	Ecology and Environment	3	0	0	3
2.	CL5019	Industrial Pollution Prevention	3	0	0	3
3.	CL5020	Environmental Policies and Legislation	3	0	0	3
4.	CL5021	Remote Sensing and GIS applications in Environmental Management	3	0	0	3
5.	CL5022	Atmospheric science	3	0	0	3
6.	CL5023	Green Chemistry and Engineering	3	0	0	3
7.	CL5024	Environmental Nanotechnology	3	0	0	3
8.	EV5002	Environmental Sustainability	3	0	0	3
9.	EV5003	Environmental Risk Assessment	3	0	0	3
10.	EV5004	Soil Remediation Technologies	3	0	0	3
11.	CL5025	Environmental health and safety in industries	3	0	0	3
12.	CL5026	Industrial instrumentation	3	0	0	3
13.	CL5072	Design of experiments	3	0	0	3
14.	CL5027	Risk Analysis and Hazop	3	0	0	3
15.	EV5005	Environmental Management	3	0	0	3
16.	EV5006	Principles of cleaner production	3	0	0	3

17.	CL5028	Environmental Biotechnology	3	0	0	3
18.	EV5007	Waste Management and Energy Recovery	3	0	0	3
19.	CL5029	Advanced Oxidation Processes and Technology	3	0	0	3
20.	CL5030	Electrochemical Environmental Technology	3	0	0	3

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. No.	Code No.	Course Title	Periods Per Week			Credits	Semester
			L	T	P		
1	RM5151	Research Methodology and IPR	2	0	0	2	1

OPEN ELECTIVE COURSES [OEC]*

*(Out of 6 Courses one Course must be selected)

S.NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	OE5091	Business Data Analytics	3	0	0	3	3
2.	OE5092	Industrial Safety	3	0	0	3	3
3.	OE5093	Operations Research	3	0	0	3	3
4.	OE5094	Cost Management of Engineering Projects	3	0	0	3	3
5.	OE5095	Composite Materials	3	0	0	3	3
6.	OE5096	Waste to Energy	3	0	0	3	3

AUDIT COURSES (AC)

Registration for any of these courses is optional to students

S. NO.	COURSE CODE	COURSETITLE	PERIODSPERWEEK			CREDITS	SEMESTER
			Lectur	Tutorial	Practical		
1.	AX5091	English for Research Paper Writing	2	0	0	0	1/2
2.	AX5092	Disaster Management	2	0	0	0	
3.	AX5093	Sanskrit for Technical Knowledge	2	0	0	0	
4.	AX5094	Value Education	2	0	0	0	
5.	AX5095	Constitution of India	2	0	0	0	
6.	AX5096	Pedagogy Studies	2	0	0	0	
7.	AX5097	Stress Management by Yoga	2	0	0	0	
8.	AX5098	Personality Development Through Life Enlightenment Skills	2	0	0	0	
9.	AX5099	Unnat Bharat Abhiyan	2	0	0	0	

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. No.	Code No.	Course Title	Periods Per Week			Credits	Semester
			L	T	P		
1	EV5213	Mini Project with Seminar	0	0	2	1	2
2	EV5311	Project Phase I	0	0	12	6	3
3	EV5411	Project Phase II	0	0	24	12	4

SUMMARY

S. No.	Subject Area	Credits per Semester				Credits Total
		I	II	III	IV	
1	PCC	17	14	-	-	31
2	PEC	3	6	6	-	15
3	OEC	-	-	3	-	3
4	EEC	-	1	6	12	19
5	RMC	2	-	-	-	2
	Total	22	20	15	12	**70**
	Audit courses (Non Credit)	*	*			

SYLLABI

SEMESTER I

EV5101 UNIT OPERATIONS AND UNIT PROCESSES IN ENVIRONMENTAL TECHNOLOGY **L T P C**

OBJECTIVES **3 1 0 4**

- To learn about unit processes and operations.
- To make the students understand the applications of unit operations and processes in environmental technology.

UNIT I **12**

Selection of unit operations and processes - Principal type of Reactors -Screening -Mixing -Coagulation and Flocculation – Flow equalization

UNIT II **12**

Sedimentation - Type of settling - Removal ratio – Clarifier-thickener- Column flotation- air flotation.

UNIT III **12**

Filtration – classification of filters-Head loss through filters– Darcy equation.

UNIT IV **12**

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

UNIT V **12**

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

TOTAL: 60 PERIODS

COURSE OUTCOMES:

This course will make the students to

CO1: Understand the fundamentals of unit operation involve in Environmental process
CO2: Understand the basics of Coagulation and Flocculation, Reactor types
CO3: Understand the basics of Sedimentation - settling - Clarifier- flotation.
CO4: Understand the concept of Adsorption - Isotherms, chlorination
CO5: Understand the concept of Suspended and attached growth processes
CO6: Understand the concept of Aerobic and Anaerobic –processes

REFERENCES

1. Metcalf and Eddy, "Wastewater Engineering - Treatment, Disposal, and Reuse", Fourth Edition, Tata McGraw-Hill, 1995.
2. Casey. T.J. "Unit Treatment Processes in Water and Wastewater Engineering", John Wiley & Sons, 2006.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Understand the fundamentals of unit operation involve in Environmental process	3	3	3	2	2	-	2	1	1	1	1	3	3	3	3
CO2	Understand the basics of Coagulation and Flocculation, Reactor types	3	3	3	2	2	1	2	1	1	1	1	3	3	3	3
CO3	Understand the basics of Sedimentation - settling - Clarifier-flotation.	3	3	3	2	2	1	2	1	1	1	1	3	3	3	3
CO4	Understand the concept of Adsorption - Isotherms, chlorination	3	3	3	2	2	1	2	1	1	1	1	3	3	3	3
CO5	Understand the concept of Suspended and attached growth processes	3	3	3	2	1	1	2	1	1	1	1	3	3	3	3
CO6	Understand the concept of Aerobic and Anaerobic –processes	3	3	3	2	1	1	2	1	1	1	1	3	3	3	3
	Overall	3	3	3	2	2	1	2	1	1	1	1	3	3	3	3

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

EV5102

BIOLOGICAL WASTE WATERTREATMENT

L	T	P	C
3	0	0	3

OBJECTIVES

- To learn about the methods used for the treatment of wastewater biologically.
- To make the students understand modeling and design aspects of biological techniques available.

UNIT I FUNDAMENTAL OF BIOCHEMICAL OPERATIONS AND STOICHIOMETRY 9

Classification and fundamental of Biochemical Operations: role, classification and overview of biochemical operations, types of microorganism and their role, microbial eco system, stoichiometry and kinetics of biochemical reactions

UNIT II MODELLING OF SUSPENDED GROWTH REACTORS 9

Modelling Suspended Growth Systems, Aerobic Growth of Heterotrophs in a Single Continuous Stirred Tank, Reactor, Techniques for evaluating Kinetic and Stoichiometry Parameter

UNIT III APPLICATION OF SUSPENDED GROWTH REACTORS 9

Design and Evaluation of Suspended Growth Processes, Activated Sludge, Biological Nutrient Removal, Aerobic-digestion, Anaerobic Processes, Lagoons

UNIT IV MODELING OF ATTACHED GROWTH REACTORS 9

Bio-film Modeling Aerobic Growth of Biomass in Packed Towers, Rotating Biological Contactor, Fluidized Bed Biological Reactors

UNIT V APPLICATION OF ATTACHED GROWTH REACTORS 9

Trickling Filter, Submerged Attached Growth Bioreactors, Future Challenges of biological reactors, Industrial application of biological reactor for wastewater treatment.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

This course will make the students to

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

CO2: Apprehend the basics of suspended growth reactors and correlate with the equations

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

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

CO5: Relate to the types and applications of attached growth reactors used in wastewater treatment

CO6: Acquire a knowledge of the technological configuration of industrial wastewater treatment plants and reactors

REFERENCES

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, NewDelhi, 2008

Course Articulation Matrix

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	Understand the concepts and fundamentals of biochemical operations used in wastewater treatment	-	-	1	1	3	1	-	1	1	-	-	-	1	-	-
CO2	Apprehend the basics of suspended growth reactors and correlate with the equations	-	-	2	1	-	1	-	1	1	1	-	2	2	1	1
CO3	Identify the types and applications of suspended growth reactors used in wastewater treatment	-	-	2	2	2	1	-	1	-	2	1	-	1	-	-
CO4	Learn the mechanism and operations of attached growth reactors used in wastewater treatment	-	-	2	3	2	2	-	-	1	2	3	3	1	2	2
CO5	Relate to the types and applications of attached growth reactors used in wastewater treatment	-	-	2	3	2	3	-	-	2	3	3	-	2	3	3
CO6	Acquire a knowledge of the technological configuration of industrial wastewater treatment plants and reactors	-	-	1	3	2	2	-	-	2	3	3	3	3	3	3
Overall		-	-	3	3	3	2	-	1	2	3	3	3	2	3	3

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

EV5103 **AIR POLLUTION CONTROL ENGINEERING**

	L	T	P	C
OBJECTIVE	**3**	**0**	**0**	**3**

- To illustrate the air pollution sources, characteristics and effects of air and noise pollution and the methods of controlling the same. The student is expected to know about source inventory and control mechanism.

UNIT I **9**

Introduction to Air Quality; 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; Basic Properties and Terminology.

UNIT II **9**

Industrial Air Pollution Sources and Prevention; Air Pollution in the Chemical Process, 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 **9**

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

UNIT IV **9**

Prevention Versus Control; Pollution Prevention: Principles of Pollution Prevention; Methods of Particulate Collection; Methods for Cleaning Gaseous Pollutants, Environmental Cost Accounting; Total Cost Accounting Terminology;

UNIT V **9**

Noise pollution –sound level-measuring transient noise-acoustic environment health effects of noise –noise control. Introduction to cosmic pollution

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand 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: Relate the indoor air quality behaviour and its measurement
CO5: Control the air pollution using various devices and cost accounting
CO6: Analyze the environmental health effects using air and noise pollution.

TEXT BOOKS

1. Lawrence K. Wang, Norman C. Parelra, Yung Tse Hung, Air Pollution Control Engineering, Tokyo, 2004.
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.

REFERENCES

1. Arthur C.Stern, ‘Air Pollution (Vol.I – Vol.VIII)’, Academic Press, 2006.
2. Wayne T.Davis, ‘Air Pollution Engineering Manual’, John Wiley & Sons, Inc., 2000.

Course Articulation Matrix:

Course Outcomes	statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Understand the nature and characteristics of air pollutants, noise pollution and basic concepts of air quality management.	3	3	3	2	3	2	2	2	3	2	2	2	2	2	2
CO2	Identify, formulate and solve air and noise pollution problems	3	3	3	2	3	2	3	2	3	2	1	2	1	1	1
CO3	Design stacks and particulate air pollution control devices to meet applicable standards	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	Relate the indoor air quality behaviour and its measurement	3	3	3	3	2	3	3	3	3	3	2	2	3	2	2
CO5	Control the air pollution using various devices and cost accounting	3	2	3	3	3	2	3	3	3	1	2	2	1	3	3
CO6	Analyze the environmental health effects using air and noise pollution.	3	2	1	2	3	2	3	3	2	3	2	3	2	1	1
Overall		3	3	3	3	3	2	3	3	3	2	2	2	2	2	2

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

EV5104 **SOLID AND HAZARDOUS WASTE MANAGEMENT**

L	T	P	C
3	0	0	3

OBJECTIVE

- Students will gain knowledge about valuing the environment and make it cleaner and greener by safe disposal of solid wastes

CO1: Be familiar with legislation pertaining to solid waste management

CO2: Be familiar with solid waste remedial measures and their importance.

CO3: Understand the knowledge of energy production using solid wastes.

CO4: Understand the knowledge of the toxicity of materials over the environment

CO5: Be familiar with the sampling of solid wastes and its analysis

CO6: Will get better knowledge about the safe disposal of solid wastes

UNIT I **9**

Legal and Organizational foundation: Definition of solid waste - waste generation in a technological society - sources and types of solid waste –legislations on management and handling of municipal solid wastes, hazardous wastes, biomedical wastes, batteries waste, E-waste and plastics, monitoring responsibilities-waste minimization at source

UNIT II **9**

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 through 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 and leachate collection systems - requirements and technical solutions, designated waste landfill remediation - Integrated waste management facilities

UNIT III **9**

Definition and identification of hazardous wastes - sources and characteristics - hazardous wastes in Municipal Waste - Hazardous waste regulations -minimization of Hazardous Waste-compatibility, handling and storage of hazardous waste - collection and Transport-hazardous waste management practice in India

UNIT IV **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 **9**

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Be familiar with legislation pertaining to solid waste management

CO2: Be familiar with solid waste remedial measures and their importance.

CO3: Understand the knowledge of energy production using solid wastes.

CO4: Understand the knowledge of the toxicity of materials over the environment

CO5: Be familiar with the sampling of solid wastes and its analysis

CO6: Will get better knowledge about the safe disposal of solid wastes

TEXT 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 Organisation, Government of India, New Delhi, 2000.
5. Vesilind P.A., Worrell W and Reinhart, Solid waste Engineering, Thomson Learning Inc., Singapore, 2002.

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	Be familiar with legislation pertaining to solid waste management	3	2	3	2	3	2	2	3	2	3	2	2	3	2	2
CO2	Be familiar with solid waste remedial measures and their importance.	-	-	2	2	3	2	3	-	-	2	2	3	2	3	3
CO3	Understand the knowledge of energy production using solid wastes.	3	-	3	-	2	2	3	2	3	-	-	-	-	-	-
CO4	Understand the knowledge of the toxicity of materials over the environment	2	-	-	-	2	2	2	3	2	3	2	2	3	3	3
CO5	Be familiar with the sampling of solid wastes and its analysis	3	-	3	-	2	2	3	2	3	-	2	2	3	3	3
CO6	Will get better knowledge about the safe disposal of solid wastes	1	2	-	2	3	1	2	-	3	2	1	3	2	2	2
Overall		3	2	3	2	3	2	3	3	3	3	2	3	3	3	3

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

RM5151 RESEARCH METHODOLOGY AND IPR LT P C
2 0 0 2

COURSE OBJECTIVES:

To impart knowledge and skills required for research and IPR:

- Problem formulation, analysis and solutions.
- Technical paper writing / presentation without violating professional ethics
- Patent drafting and filing patents.

UNIT I RESEARCH PROBLEM FORMULATION 6

Meaning of research problem- Sources of research problem, criteria characteristics of a good research problem, errors in selecting a research problem, scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations

UNIT II LITERATURE REVIEW 6

Effective literature studies approaches, analysis, plagiarism, and research ethics.

UNIT III TECHNICALWRITING /PRESENTATION 6

Effective technical writing, how to write report, paper, developing a research proposal, format of research proposal, a presentation and assessment by a review committee.

UNIT IV INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT V INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology.Patent information and databases.Geographical Indications. New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc.

Traditional knowledge Case Studies, IPR and IITs.

TOTAL: 30 PERIODS

COURCE OUTCOMES:

1. Ability to formulate research problem
2. Ability to carry out research analysis
3. Ability to follow research ethics
4. Ability to understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity
5. Ability to understand about IPR and filing patents in R & D.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										
CO2	✓											
CO3	✓							✓				
CO4	✓				✓							
CO5	✓					✓						✓

REFERENCES:

1. Asimov, “Introduction to Design”, Prentice Hall, 1962.
2. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
3. Mayall, “Industrial Design”, McGraw Hill, 1992.
4. Niebel, “Product Design”, McGraw Hill, 1974.
5. Ranjit Kumar, 2nd Edition, “Research Methodology: A Step by Step Guide for beginners” 2010

EV5111 **ENVIRONMENTAL ENGINEERING LABORATORY –I**

L	T	P	C
0	0	4	2

OBJECTIVE

- The course is designed to develop sampling and analytical skills of the students which are required in environmental monitoring.

1. Determination of Acidity and Alkalinity, Chlorides
2. Dissolved and undissolved solids and settleable solids, determination
3. Measurement of turbidity and Jar test
4. Soil analysis: moisture & pH determination, organic content
5. Ground Water and Drinking Water sampling & Analysis.
6. Measurement of heavy metals
7. analysis of trace organic contaminants, using GC-MS
8. Measurement of viscosity
9. Measurement of surface tension

TOTAL: 60 PERIODS

COURSE OUTCOMES

CO1: The students will know various standard protocols used in environmental monitoring.

CO2: Perform common environmental experiments relating to water and wastewater quality, and know which tests are appropriate for given environmental problem

CO3: Understand and use the water and wastewater sampling procedures and sample preservations.

CO4: Statistically analyze and interpret laboratorial results

CO5: Demonstrate the ability to work in groups

CO6: Demonstrate the ability to write clear technical laboratorial reports

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	The students will know various standard protocols used in environmental monitoring.	2	1	2	3	3	2	3	3	2	2	2	3	3	2	2
CO2	Perform common environmental experiments relating to water and wastewater quality, and know which tests are appropriate for given environmental problem	3	1	2	3	3	2	3	3	3	2	2	3	3	2	2
CO3	Understand and use the water and wastewater sampling procedures and sample preservations.	3	1	2	3	2	2	3	3	3	2	2	2	3	2	2
CO4	Statistically analyze and interpret laboratorial results	3	1	2	3	3	2	3	3	3	2	2	3	3	2	2
CO5	Demonstrate the ability to work in groups	3	1	2	2	3	2	3	3	3	2	2	3	3	2	2
CO6	Demonstrate the ability to write clear technical laboratorial reports	3	1	2	3	3	2	3	3	3	2	2	3	2	2	2
Overall		3	1	2	3	3	2	3	3	3	2	2	3	3	2	2

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

EV5112 **SEPARATION PROCESSES IN ENVIRONMENTAL APPLICATIONS LABORATORY**

L	T	P	C
0	0	4	2

OBJECTIVE

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

LIST OF EXPERIMENTS

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

TOTAL: 60 PERIODS

COURSE OUTCOMES

The students will be able to

CO1: Perform distillation and Determine Distillation parameters

CO2: Evaluate the performance and determine Extraction parameters

CO3: Estimate the Adsorption/Absorption parameters

CO4: Analyse and perform separation using Ion-Exchange operation

CO5: Analyse and determine various Filtration parameters

CO6: Perform sieve analysis and to Analyse the drying characteristics of a Dryer

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	Perform distillation and Determine Distillation parameters	3	1	2	3	3	2	3	3	3	2	2	3	3	2	2
CO2	Evaluate the performance and determine Extraction parameters	3	1	2	3	3	2	3	3	3	2	2	3	3	2	2
CO3	Estimate the Adsorption/Absorption parameters	3	1	2	3	3	2	3	3	3	2	2	3	3	2	2
CO4	Analyse and perform separation using Ion-Exchange operation	3	1	2	3	3	2	3	3	3	2	2	3	3	2	2
CO5	Analyse and determine various Filtration parameters	3	1	2	3	3	2	3	3	3	2	2	3	3	2	2
CO6	Perform sieve analysis and to Analyse the drying characteristics of a Dryer	3	1	2	3	3	2	3	3	3	2	2	3	3	2	2
Overall		3	2	3	3	3	3	3	3	3	3	3	3	3	3	3

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

SEMESTER II

EV5201 SEPARATION PROCESSES IN ENVIRONMENTAL APPLICATIONS

L	T	P	C
2	1	0	3

OBJECTIVE

- To learn about the different separation processes available. Also to make the students understand the fundamental mathematical concepts behind the various separation processes.

UNIT I **10**

Pollution sources, Environmental separations - Historic perspective of environmental pollution- Separation mechanisms - Equilibrium-based processes, Rate - based processes, Counter current operation, Productivity and selectivity, separating agents

UNIT II **10**

Degrees of freedom analysis, Phase equilibrium, Equilibrium-limited analysis, Minimum number of stages, Rate-limited processes, Batch and Continuous distillation, Extraction in Environmental applications, Leaching processes, McCabe–Thiele analysis

UNIT III **9**

Absorption and stripping, packed columns, Adsorption principles, Sorbent selection, regeneration, Transport processes, Process design factors, Design of fixed-bed adsorber.

UNIT IV **8**

Ion exchange- Objectives, Environmental applications, Ion-exchange mechanisms, Ion exchange media, Equipment and design procedures.

UNIT V **8**

Membranes - Merits and demerits of membrane processes, membrane materials, membrane modules, Environmental applications, Separation mechanisms - Membrane processes, membrane performance.

TOTAL: 45 PERIODS

COURSE OUTCOMES

On successful completion of the course, the students will be able to

CO1: Identify the nature of pollutants and understand the mechanism of various chemical engineering separation processes.

CO2: Understand the equilibrium relationships, understand the fundamental concepts of distillation, extraction & leaching and perform design calculations

CO3: Design the towers for gas–liquid and fluid – solid operations for environmental applications.

CO4: Understand the Ion exchange mechanism and design the system for environmental application

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

CO6: Select the appropriate separation techniques for a given problem.

REFERENCES

1. Noble, R.D and Terry P.A., Principles of Chemical Separations with Environmental Applications, Cambridge University Press, 2004.
2. Treybal R E, Mass Transfer Operations, McGraw Hill 1981.
3. Seader J D and Henley E J, Separation Processes Principles, 3rd Edition, John Wiley & Sons, 2011.

Course Articulation Matrix

Course Outcomes	Statements	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Identify the nature of pollutants and understand the mechanism of various chemical engineering separation processes.	3	2	3	3	2	1	1	1	1	1	2	-	3	2	2
CO2	Understand the equilibrium relationships, understand the fundamental concepts of distillation, extraction & leaching and perform design calculations	3	2	3	3	2	1	1	1	1	1	2	-	3	2	2
CO3	Design the towers for gas–liquid and fluid – solid operations for environmental applications.	3	2	3	3	2	1	1	1	1	1	2	-	3	2	2
CO4	Understand the Ion exchange mechanism and design the system for environmental application	3	2	3	3	2	1	1	1	1	1	2	-	3	2	2
CO5	Understand the basic principle, different types of membrane, membrane modules and various membrane process and its mechanisms.	3	2	3	3	2	1	1	1	1	1	2	-	3	2	2
CO6	Select the appropriate separation techniques for a given problem.	3	2	3	3	2	1	1	1	1	1	2	-	3	2	2
Overall		3	2	3	3	2	1	1	1	1	1	2	-	3	2	2

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

EV5202 MODELING OF ENVIRONMENTAL SYSTEMS

	L	T	P	C
OBJECTIVES	**3**	**1**	**0**	**4**

- To understand the basics of model construction.
- To learn about the calibration and validation of the models

UNIT I ENVIRONMENTAL SYSTEMS 12

Principles of Environmental modeling, model building and types, classification of mathematical models, Model Calibration, Validation, Verification and Sensitivity Analysis, uncertainty sources, methods of solution, types of environmental models.

UNIT II ECOLOGICAL SYSTEM 12

Population Dynamics: Birth and death processes. 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.

UNIT III HYDROLOGICAL SYSTEM 12

Climate system modeling, Basic mechanisms of river self-purification, Streeter-Phelps and Dobins models, More complex chemical and ecological models, Pollutant and nutrient dynamics, Dissolved Oxygen dynamics.

UNIT IV MICROBIAL SYSTEM 12

Fundamentals of microbial dynamics, Pollutant/Microorganisms interactions, microbial dynamics calculations, Process schemes: CSTR, plug-flow, SBR, Anaerobic digestion: process dynamics, Operational control of wastewater treatment processes.

UNIT V ENVIRONMENTAL APPLICATIONS 12

Introduction to CFD fundamentals, Applications of CFD in environmental modeling, Fuzzy System Modeling- Introduction to fuzzy sets and systems, Cluster analysis for the classification of ecological data.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

This course will make the students to

CO1: The students will gain knowledge on modeling environmental systems

CO2: Students will get trained about ecology and multidimensional modeling

CO3: Students will gain knowledge in hydrology and behavioural systems.

CO4: The students will adapt themselves to model interactive systems.

CO5: Be familiar with fuzzy logic based models.

REFERENCES

1. Deaton, M.L and Winebrake, J.J., Dynamic Modeling of Environmental Systems, Verlag, 2000.
2. Orhon, D and Artan, N., Modeling of Activated Sludge Systems, Technomic Publ.Co., 1994.
3. Chapra, S.C. Surface Water-Quality Modeling, McGraw-Hill, 2008.
4. Schnoor, J.L., Environmental Modeling Fate and Transport of Pollutants in Water, Air and Soil, John Wiley & Sons Inc., New York, 1996.

Course Articulation Matrix

Course Outcomes	Statements	Program Outcomes														
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO 2	PSO3
CO1	The students will gain knowledge on modeling environmental systems	3	2	-	3	-	3	1	3	1	1	3	2	3	2	2
CO2	Students will get trained about ecology and multidimensional modeling	3	3	1	3	-	3	1	3	3	-	2	3	2	3	3
CO3	Students will gain knowledge in hydrology and behavioural systems.	3	-	2	3	1	1	-	-	-	-	1	1	3	3	3
CO4	The students will adapt themselves to model interactive systems.	3	2	3	3	1	1	1	1	1	1	1	1	3	2	2
CO5	Be familiar with fuzzy logic based models.	1	1	2	3	-	2	-	-	-	-	1	1	2	3	3
Over all		3	2	2	3	1	2	1	1	1	1	1	1	3	3	3

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

EV5203 ENVIRONMENTAL IMPACT ASSESSMENT

	L	T	P	C
OBJECTIVE	**3**	**0**	**0**	**3**

- To educate the graduates about the importance of Environmental Impact Assessment and to make them understand the methods followed for the impact assessment.

UNIT I **9**

Environmental Impact Assessment (EIA) - Environmental Impact Statement (EIS), Environmental Risk Assessment (ERA) - Legal and Regulatory aspects in India – Types and limitations of EIA - Terms of Reference in EIA- Issues in EIA - national – cross-sectoral - social and cultural.

UNIT II **12**

Components - screening - setting - analysis - prediction of impacts - mitigation. Matrices - Networks - Checklists. Importance assessment techniques - cost-benefit analysis - analysis of alternatives - methods for Prediction and assessment of impacts - air - water - soil - noise - biological - cultural - social - economic environments. Standards and guidelines for evaluation. Public Participation in environmental decision-making.

UNIT III **6**

Trends in EIA practice and evaluation criteria - capacity building for quality assurance. Expert system in EIA - use of regulations and AQM.

UNIT IV **9**

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

UNIT V **9**

Case studies of EIA of developmental projects

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the Environmental Impact and Environmental Risk assessments and related legal procedures.

CO2: Understand various components and assessment techniques of EIA.

CO3: Aware of Standards and guidelines for evaluation procedures.

CO4: Make decisions on the environmental consequences of proposed actions.

CO5: Understand document planning and environmental monitoring through EIA

CO6: Get greater insight about EIA through various case studies promote environmentally sound and sustainable development by identifying appropriate measures.

REFERENCES

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.

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Understand the Environmental Impact and Environmental Risk assessments and related legal procedures.	-	2	3	3	2	-	1	-	2	2	2	1	1	2	1
CO2	Understand various components and assessment techniques of EIA.	-	2	2	3	1	1	1	-	2	2	2	1	1	2	1
CO3	Aware of Standards and guidelines for evaluation procedures.	-	1	2	3	1	1	1	-	2	1	2	1	1	2	1
CO4	Make decisions on the environmental consequences of proposed actions.	-	2	2	3	2	-	1	-	2	2	1	1	1	2	1
CO5	Understand document planning and environmental monitoring through EIA	-	2	3	2	1	1	1	2	2	1	2	1	1	2	1
CO6	Get greater insight about EIA through various case studies promote environmentally sound and sustainable development by identifying appropriate measures.	-	2	2	3	1	-	1	-	2	2	1	1	1	1	1
Over all		-	2	2	3	2	1	1	1	2	2	2	1	1	2	1

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

EV5211 ENVIRONMENTAL ENGINEERING LABORATORY –II

L	T	P	C
0	0	4	2

OBJECTIVE

To make students gain practical knowledge on various analysis and treatment systems in pollution treatment techniques and its application.

LIST OF EXPERIMENTS

1. Studies on isolation of microorganism for wastewater treatment.
2. Sampling and analysis of air pollutants ambient and stacks (SPM, RPM, SO2, NOX and CO).
3. Physiochemical analysis of solid wastes.
4. Design of clarifier by using the data obtained through batch sedimentation.
5. Coagulation and flocculation for removal of suspended solids from water.
6. Water softening.
7. Biological aerobic treatment for removal of organic
8. Studies on treatment of effluents using electrochemical reactor.
9. Batch adsorption studies using activated carbon and dye.
10. Treatment of wastewater by Advanced Oxidation Technology

TOTAL: 60 PERIODS

COURSE OUTCOMES

CO1: Students will know how to isolate microorganism from wastewater

CO2: Will be able to evaluate the air pollutant parameters

CO3: will understand the Adsorption/Absorption mechanism

CO4: To perform batch operation for the treatment of wastewater.

CO5: Will be capable of Analysing and determining COD/BOD

CO6: We know the mechanism involved in AOP techniques

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Students will know how to isolate microorganism from wastewater	2	1	2	3	3	2	3	3	2	2	2	3	3	2	2
CO2	Will be able to evaluate the air pollutant parameters	3	1	2	3	3	2	3	3	3	2	2	3	3	2	2
CO3	will understand the Adsorption/Absorption mechanism	3	1	2	3	2	2	3	3	3	2	2	2	3	2	2
CO4	To perform batch operation for the treatment of wastewater.	3	1	2	3	3	2	3	3	3	2	2	3	3	2	2
CO5	Will be capable of Analysing and determining COD/BOD	3	1	2	2	3	2	3	3	3	2	2	3	3	2	2
CO6	We know the mechanism involved in AOP techniques	3	1	2	3	3	2	3	3	3	2	2	3	2	2	2
Over all		3	1	2	3	3	2	3	3	3	2	2	3	3	2	2

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

EV5212 **ADVANCED OXIDATION PROCESS LABORATORY**

L	T	P	C
0	0	4	2

OBJECTIVE

- To develop sound practical knowledge for students on different types of Advanced Oxidation Process

COURSE OUTCOMES

The students will be able to

CO1: Determine the rate constant experimentally for different AOP.

CO2: Determine the rate constant experimentally for different sequential AOP.

CO3: Determine the rate constant experimentally for different combined AOP.

CO4: Determination of power/energy for different AOP

CO5: Determination of band gap energy for photo- catalyst.

CO6: Understand the Design of experiments software tool for parameter optimization.

LIST OF EXPERIMENTS

1. Kinetic studies of ozonation process
2. Kinetic studies of Sonocatalysis process
3. Kinetic studies of Photocatalysis under visible light
4. Kinetic studies of Photocatalysis under UV light
5. Kinetic studies of electro-oxidation process
6. Kinetic study of Photo Fenton process
7. Kinetic study of sequential AOP
8. Kinetic study of combined AOP
9. Study of energy/power calculation for different AOP
10. Determination of band gap energy of photo - catalyst.
11. Design of experiments to analyze the results.

TOTAL: 60 PERIODS

COURSE OUTCOMES

The students will be able to

CO1: Determine the rate constant experimentally for different AOP.

CO2: Determine the rate constant experimentally for different sequential AOP.

CO3: Determine the rate constant experimentally for different combined AOP.

CO4: Determination of power/energy for different AOP

CO5: Determination of band gap energy for photo- catalyst.

CO6: Understand the Design of experiments software tool for parameter optimization.

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Determine the rate constant experimentally for different AOP.	3	3	3	3	2	1	1	1	2	3	2	2	3	3	3
CO2	Determine the rate constant experimentally for different sequential AOP.	3	3	3	2	2	1	1	1	2	3	2	2	3	3	3
CO3	Determine the rate constant experimentally for different combined AOP.	3	3	3	2	2	1	1	1	2	3	2	2	3	3	3
CO4	Determination of power/energy for different AOP	3	3	3	2	2	1	1	1	2	3	2	2	3	3	3
CO5	Determination of band gap energy for photo- catalyst.	3	3	3	3	2	1	1	1	2	3	2	2	3	3	3
CO6	Understand the Design of experiments software tool for parameter optimization.	3	3	3	3	2	1	1	1	2	3	2	2	3	3	3
Over all		3	3	3	3	2	1	1	1	2	3	2	2	3	3	3

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

EV5213 **MINI PROJECT WITH SEMINAR**

	L	T	P	C
OBJECTIVE	**0**	**0**	**2**	1

- To provide exposure to the recent developments, and to improve the student's presentation skills.

COURSE OUTCOMES:

The students will be able to

CO1: Know the latest improvements in their field of expertise

CO2: Relate the significant works of literature for the selected and suitable topic

CO3: Focus the salient features of the area of study

CO4: Understand the basic concepts and mechanism related to the problem

CO5: Improve the presentation on the topic

CO6: Practice their presentation in written and oral skills

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Know the latest improvements in their field of expertise	3	3	3	2	3	2	2	2	3	2	2	2	2	2	2
CO2	Relate the significant works of literature for the selected and suitable topic	2	3	3	2	3	2	3	2	3	2	1	2	1	1	1
CO3	Focus the salient features of the area of study	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	Understand the basic concepts and mechanism related to the problem	3	3	3	3	2	3	3	3	3	3	2	2	3	2	2
CO5	Improve the presentation on the topic	3	2	3	3	3	2	3	3	3	1	2	2	1	3	3
CO6	Practice their presentation in written and oral skills	3	2	1	2	3	2	3	3	2	3	2	3	2	1	1
Over all		3	3	3	3	3	2	3	3	3	2	2	2	2	2	2

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

SEMESTER III

EV5311 **PROJECT PHASE I**

	L	T	P	C
OBJECTIVES	**0**	**0**	**12**	**6**

- To identify a specific problem related to environment and collecting information related to the same through detailed literature review.
- To identify a methodology to carry out the project.
- To guide the students in preparing project reports, to present their findings in reviews and viva-voce examination.

The student individually works on a specific topic selected by him/her which is relevant to his/her specialization of the programme approved by a faculty member who is familiar in the particular area of interest. The topic may be experimental or analytical or case studies. At the end of the semester, a detailed report on the work done should be submitted which contains a clear definition of the identified problem, detailed literature review related to the area of work and methodology for carrying out the work. The students will be evaluated through reviews internally by panel members and a final viva-voce examination conducted at the end of the semester by a panel of one internal and one external examiner.

TOTAL: 180 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: The students will be in a position to do literature survey for any type of environmental problems.

CO2: At the end of the course, the students will have a clear idea of his/her area of work and they will be in a position to carry out the remaining phase II work in a systematic way.

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	The students will be in a position to do literature survey for any type of environmental problems.	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3
CO2	At the end of the course, the students will have a clear idea of his/her area of work and they will be in a position to carry out the remaining phase II work in a systematic way.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Over all		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

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

SEMESTER IV

EV5411 **PROJECT PHASE II**

	L	T	P	C
OBJECTIVE	**0**	**0**	**24**	**12**

- To carry out experiments to solve the identified problem based on the identified methodology.
- To develop skills to analyze and discuss the results obtained and make conclusions.

The student should continue the phase I work on the selected topic as per the identified methodology. After completing the work to the satisfaction of the supervisor and review committee a detailed report should be prepared and submitted to the head of the department at the end of the semester. The students will be evaluated based on the reviews and the viva-voce examination conducted by a panel of examiners including one external examiner.

TOTAL: 360 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: On completion of the project work, students will be in a position to carry out further research at pilot plant level in their field and publish their work in reputed journals

CO2: Students will have confidence in identifying the cause and solutions to any environmental pollution related problems.

Course Articulation Matrix:

Course Outcomes	Program Outcomes														
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Over all	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

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

PROFESSIONAL ELECTIVE COURSES [PEC]

EV5001 ECOLOGY AND ENVIRONMENT

L	T	P	C
3	0	0	3

OBJECTIVE

Students will learn about the structural and functional interactions between the ecological systems and the environment which would help in applications to the prevalent problems in the society.

UNIT I **10**

OBJECTIVE - scope and applications of Ecology, Ecological Engineering and Ecotechnology 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 **10**

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 **10**

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 **10**

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 **5**

Ecological Effects of Warfare, Effects of Stress on Ecosystem Structure and Function, Case studies of integrated ecological engineering systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the fundamentals of ecological systems and their relation with engineering and environment

CO2: Understand the principles in the modeling of environmental systems and design of ecological economic systems

CO3: Carry out engineering studies based on ecological criteria

CO4: Understand the principles and applications in the water management system

CO5: Understand the concept of various systems and their human modification

CO6: Find solutions to problems pertaining to environmental issues.

TEXT BOOKS

1. Engineering within ecological Constraints, Edited by Peter C. Schulze, National academy of engineering national academy press Washington, D.C. 1996
2. Environmental Ecology, 1st Edition by Bill Freedman, Academic Press, 1989.

REFERENCES

1. Ignaci Muthu S, ‘Ecology and Environment’ Eastern Book Corporation, 2007.
2. Krebs, Charles J. 2001. Ecology: The Experimental Analysis of Distribution and Abundance. 5th edition.
3. Mitsch, J.W. and Jorgensen, S.E., Ecological Engineering, An Introduction to Ecotechnology, John Wiley & Sons, New York, 1989.
4. Ecology and Environment, 1st Edition. R.N Bhargava, V. Rajaram, Keith Olson, Lynn Tiede, CRC press, 2018.

Course Articulation Matrix

Course Outcomes	Statements	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Understand the fundamentals of ecological systems and their relation with engineering and environment	3	3	2	-	1	-	-	-	-	-	1	-	3	3	2
CO2	Understand the principles in the modeling of environmental systems and design of ecological economic systems	-	-	3	2	3	2	-	-	2	-	-	2	3	3	1
CO3	Carry out engineering studies based on ecological criteria	-	-	3	2	3	2		1	-	2	-	1	3	3	2
CO4	Understand the principles and applications in the water management system	2	-	3	-	3	-	1	-	3	-	3	1	3	3	3
CO5	Understand the concept of various systems and their human modification	1	1		-	-	-	3	-	-	-	-	3	2	1	1
CO6	Find solutions to problems pertaining to environmental issues.	-	-	3	3	2	-	-	1	3	1	-	3	3	3	2
Over all		3	2	3	3	1	2	2	1	2	1	1	3	3	3	3

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

CL5019 **INDUSTRIAL POLLUTION PREVENTION**

	L	T	P	C
OBJECTIVE	**3**	**0**	**0**	**3**

- To provide knowledge on sources and characteristics of industrial pollution, techniques and approaches for minimizing the generation of pollutants.

UNIT I **9**

Basics of Jurisprudence-Environmental law relation with other disciplines-Criminal law- Common Law-Relevant sections of the code of civil procedure, criminal procedure code - Indian Penal code.

UNIT II **9**

Fundamental Rights - Directive principles of state policy - Article 48(A) and 51-A (g) Judicial enforcibility-Constitution and resources management and pollution control-Indian forest policy (1990) –Indian Environmental policy (1992).

UNIT III **9**

Administration regulations - constitution of pollution control Boards Powers, functions, Accounts, Audit etc.-Formal Justice Delivery Mechanism Higher and Lower of judiciary- Constitutional remedies writ jurisdiction Article 32, 226, 136 special reference to madamus and certiorori for pollution abatement-Equitable remedies for pollution control.

UNIT IV **9**

Administrative regulation under recent legislations in water pollution control, Water (prevention and control of pollution)Act 1974 as Amended by amendment act 1988, Water (prevention of control and pollution) Rules1975 Water (prevention and pollution) Cess Act.1977 as amended by amendment act1991. Air (prevention and control of pollution) Act 1981 as amended by Amendment act 1987 and relevant notifications.

UNIT V **9**

Relevant notifications in connection with Hazardous Wastes (Management and handling), Biomedical Wastes (Management and Handling), Noise pollution, Eco-labelling, and EIA.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the basics of Jurisprudence related to industrial pollution.

CO2: Understand Environmental law relation with other disciplines.

CO3: Understand about Fundamental Rights and Indian Environmental Policy.

CO4: Aware of Administrative regulations and Equitable remedies for pollution control.

CO5: Understand Water and Air Acts and relevant notifications.

CO6: Understand notifications in connections with various pollutions.

REFERENCES

1. Constitution of India Eastern Book Company Lucknow 12th Edition, 1997.
2. Pandey, J.N., Constitutional Law of India, (31st Edition) Central Law of Agency, Allahabad, 1997.
3. Kesari, U.P.D, Administrative Law, Universal Book Trade, Delhi, 1998.
4. Tiwari, H.N., Environmental Law, Allahabad Law.Agency 1997.
5. Shyam Divan and Armin Roseneranz “Environmental law and policy in India “Oxford University Press, New Delhi, 2001.

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Understand the basics of Jurisprudence related to industrial pollution.	-	2	1	1	1	3	3	1	-	1	1	2	3	-	1
CO2	Understand Environmental law relation with other disciplines.	-	2	1	2	1	3	2	1	-	1	1	2	3	-	1
CO3	Understand about Fundamental Rights and Indian Environmental Policy.	-	2	1	1	1	3	2	1	-	1	1	2	3	-	1
CO4	Aware of Administrative regulations and Equitable remedies for pollution control.	-	2	1	1	1	2	2	1	-	1	1	1	3	-	1
CO5	Understand Water and Air Acts and relevant notifications.	-	2	1	2	-	3	2	1	-	1	1	2	3	-	1
CO6	Understand notifications in connections with various pollutions.	-	2	1	1	1	3	2	1	-	1	1	1	3	-	1
Over all		-	2	1	2	1	3	2	1	-	1	1	2	3	-	1

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

CL5020 ENVIRONMENTAL POLICIES AND LEGISLATION

L	T	P	C
3	0	0	3

OBJECTIVE

- Students will have an understanding of environmental policies and legislation pertaining to industries.

UNIT I INTRODUCTION 9

Indian Constitution and Environmental Protection – National Environmental policies – Environmental laws and legislation- Precautionary Principle and Polluter Pays Principle – Concept of absolute liability – multilateral environmental agreements and Protocols – Montreal Protocol, Kyoto agreement, Rio declaration – Environmental Protection Act, Water (P&CP) Act, Air (P&CP)Act – Institutional framework (SPCB/CPCB/MoEF)

UNIT II WATER (P&CP) ACT, 1974 8

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 procedures, State Water Laboratory – Appellate Authority – Penalties for violation of consent conditions etc. Provisions for closure/directions in apprehended pollution situation.

UNIT III AIR (P&CP) ACT, 1981 8

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 procedures, State Air Laboratory – Appellate Authority – Penalties for violation of consent conditions etc. Provisions for closure/directions in apprehended pollution situation.

UNIT IV ENVIRONMENT (PROTECTION) ACT 1986 13

Genesis of the Act – delegation of powers – Role of Central Government - EIA Notification – Sitting of Industries – Coastal Zone Regulation - Responsibilities of local bodies mitigation scheme etc., for Municipal Solid Waste Management - Responsibilities of Pollution Control Boards under Hazardous Waste rules and that of occupier, authorisation – Biomedical waste rules – responsibilities of generators and role of Pollution Control Boards

UNIT V OTHER TOPICS 7

Relevant Provisions of Indian Forest Act, Public Liability Insurance Act, CrPC, IPC -Public Interest Litigation - Writ petitions - Supreme Court Judgments in Landmark cases.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the fundamental national policies pertaining to environmental acts.

CO2: Understand the laws, analytical techniques involved in water pollution control

CO3: Understand the laws, analytical techniques involved in air pollution control

CO4: Understand the concept for waste management and laws involved

CO5: Understand the environmental laws and their applications

CO6: Find solutions to problems present in environment management

TEXT BOOKS

1. Environmental Law, Policy, and Economics, Reclaiming the Environmental Agenda By Nicholas A. Ashford and Charles C. Caldart. The MIT press, 2017.

REFERENCES

1. CPCB, “Pollution Control acts, Rules and Notifications issued there under “Pollution Control Series – PCL/2/1992, Central Pollution Control Board, Delhi, 1997.
2. Shyam Divan and Armin Roseneranz “Environmental law and policy in India “Oxford University Press, New Delhi, 2001.
3. GregerI.Megregor, “Environmental law and enforcement”, Lewis Publishers, London. 1994.

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Understand the fundamental national policies pertaining to environmental acts.	-	1	-	2	1	3	1	-	1	3	2	-	3	2	-
CO2	Understand the laws, analytical techniques involved in water pollution control	-	1	-	1	1	2	-	-	2	3	1	-	3	2	1
CO3	Understand the laws, analytical techniques involved in air pollution control	-	1	-	2	1	3	1	-	1	3	2	-	3	2	-
CO4	Understand the concept for waste management and laws involved	-	1	-	1	1	2	-	-	1	3	1	-	3	2	-
CO5	Understand the environmental laws and their applications	-	1	-	2	1	3	-	-	2	3	2	-	2	2	1
CO6	Find solutions to problems present in environment management	-	1	-	2	1	2	1	-	1	3	2	-	3	2	-
Over all		-	2	-	2	2	3	1	-	2	3	2	-	3	2	1

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

CL5021 REMOTE SENSING AND GIS APPLICATIONS IN ENVIRONMENTAL MANAGEMENT

	L	T	P	C
OBJECTIVE	**3**	**0**	**0**	**3**

- To impart knowledge on principles and applications of remote sensing , GIS for environmental engineering and the usage of GIS software and processing of data

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 SENSING TECHNOLOGY 9

Classification of Remote Sensing Systems, Energy recording technology, Aerial photographs, Photographic systems – Across 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 DATA PROCESSING 9

Characteristics of Remote Sensing data, Photo-grammetry – 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 – GIS software

UNIT V REMOTE SENSING AND GIS APPLICATIONS 9

Monitoring and management of environment, Conservation of resources, Sustainable land use, Coastal zone management – Limitations.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the basic principles in remote sensing.

CO2: Understand the various classification and technology in remote sensing.

CO3: Understand the characteristic of remote sensing.

CO4: Understand the analyzing technique in remote sensing and GIS.

CO5: Understand the concept of geographical information system.

CO6: Application of remote sensing and GIS in detail.

TEXT BOOKS

1. Lillesand, T.M. and Kiefer, R.W, Remote sensing and image interpretation, John Wiley and sons, New York, 2004.
2. GolfriedKonechy, Geoinformation: Remote sensing, Photogrammetry and Geographical Information Systems, CRC press, 1st Edition, 2002.
3. Burrough, P.A. and McDonnell, R.A., Principles of Geographic Information systems Oxford University Press, New York, 2001.

REFERENCES

1. Lintz, J. and Simonet, Remote sensing of Environment, Addison Wesley Publishing Company, New Jersey, 1998.
2. Pmapler and Applications of Imaging RADAR, Manual of Remote Sensing, Vol.2, ASPR, 2001.

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Understand the basic principles in remote sensing.	3	3	2	3	2	2	2	2	2	2	2	2	2	3	3
CO2	Understand the various classification and technology in remote sensing.	3	3	1	2	3	2	3	3	2	3	3	2	3	3	3
CO3	Understand the characteristic of remote sensing.	3	3	2	3	3	3	3	3	2	3	3	3	3	3	3
CO4	Understand the analyzing technique in remote sensing and GIS.	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2
CO5	Understand the concept of geographical information system.	3	2	2	3	2	3	3	3	3	3	3	3	3	3	2
CO6	Application of remote sensing and GIS in detail.	3	3	2	3	2	2	3	3	2	2	3	2	3	2	3
Over all		3	3	2	3	2	2	3	3	2	3	3	2	3	3	3

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

CL5022 **ATMOSPHERIC SCIENCE**

L	T	P	C
3	0	0	3

OBJECTIVES:

- To make the students aware of components, thermodynamics and chemistry of atmosphere.
- To make students understand the climatic changes of atmosphere and air pollution

UNIT I INTRODUCTION **9**

Scope of atmospheric science, structure of atmosphere, A brief survey of atmosphere: Stoichiometry and mass balance, chemical equilibrium, acid-base, optical properties, mass, chemical composition, winds and precipitation. – Hydrologic cycle – Carbon cycle – Climate and earth system.

UNIT II ATMOSPHERIC THERMODYNAMICS **9**

Atmospheric thermodynamics – The hydrostatic equation –adiabatic processes – water vapor in air – moisture parameters, latent heats – Normand's rule– Unsaturated air, saturated air, Equations of state for dry air and wet air.

UNIT III ATMOSPHERIC CHEMISTRY & AIR POLLUTION **9**

Composition of tropospheric air – Atmospheric circulation patterns, Sources, transport and sinks of trace gases – Tropospheric aerosols – air pollution – tropospheric chemical cycles – stratospheric chemistry.

UNIT IV ATMOSPHERIC DYNAMICS **9**

Kinematics of the large-scale horizontal flow – Dynamics of horizontal flow – primitive equations —– numerical weather prediction

UNIT V CLIMATE & WEAHTER **9**

. The present day climate – Climate variability – Climate equilibrium, sensitivity – Green house warming —– Climate monitoring and prediction – weather systems – tropical cyclones – case studies: tsunami and sea level rising, Acid rain– The concept of El Nino.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the scope of atmospheric science

CO2: Understand atmospheric thermodynamics

CO3: Understand atmospheric chemistry and air pollution

CO4: Understand the concept of numerical weather prediction

CO5: Understand climate variability of atmosphere.

CO5: Troubleshoot the problems with respect to climatic changes with the knowledge of atmospheric thermodynamics and chemistry.

REFERENCES

1. C. N. Hewitt, Andrea V. Jackson, Handbook of Atmospheric Science: Principles and Applications, Blackwell Publishing, 2003.
2. John E. Frederick, Principles of Atmospheric Science, Jones & Bartlett Publishers,2007.
3. John.M.Wallace, Peter.V.Hobbs, Atmospheric science: An introductory survey, 2nd edition, Academic press, 2006.
4. Wallace, J. M. and P. V. Hobbs, Atmospheric Science - An Introductory Survey, Academic Press, 2006

Course Articulation Matrix:

Course out comes	Statements	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Understand the scope of atmospheric science	3	1	1	1	1	-	-	-	-	-	1	1	1	1	1
CO2	Understand atmospheric thermodynamics	2	1	1	1	1	1	-	3	2	1	-	-	1	1	1
CO3	Understand atmospheric chemistry and air pollution	3	1	1	1	1	1	1	2	-	1	-	-	1	1	1
CO4	Understand the concept of numerical weather prediction	2	1	1	1	-	2	2	1	1	-	1	1	2	2	2
CO5	Understand climate variability of atmosphere.	3	2	1	1	1	-	2	2	2	-	-	-	2	2	2
CO6	Troubleshoot the problems with respect to climatic changes with the knowledge of atmospheric thermodynamics and chemistry.	3	2	1	1	-	-	2	1	1	1	-	1	1	1	1
Over all		3	2	1	1	1	1	2	2	1	1	1	2	2	2	2

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

CL5023 **GREEN CHEMISTRY AND ENGINEERING**

L	T	P	C
3	0	0	3

OBJECTIVE

- To make the students aware of global environmental issues, concepts behind pollution prevention, environmental risks, green chemistry and various methods available to evaluate environmental costs and life cycle assessments.

UNIT I **9**

Introduction, Green Chemistry – Definition , Principles of Green Chemistry and Examples, Green Chemistry Methodologies, Green Engineering – Definition, Principles of Green Engineering, Sustainability.

UNIT II **9**

Fundamental Principles 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.

UNIT III **9**

Pollution Prevention- Pollution Prevention Concepts and Terminology. Risk-Based Environmental Law. Risk and Hazard Assessment. Chemical Process Safety. Responsibilities for Environmental Protection. Environmental Persistence. Classifying Environmental Risks Based on Chemical Structure. Exposure Assessment for Chemicals in the Ambient Environment

UNIT IV **9**

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. A Framework for Evaluating Environmental Costs - Hidden Environmental Costs, Liability Costs, Internal Intangible Costs, External Costs.

UNIT V **9**

Introduction to Product Life Cycle Concepts. Life-Cycle Assessment. Life-Cycle Impact Assessments. Streamlined Life-Cycle Assessments. Uses of Life-Cycle Studies. Process Energy Integration. Process Mass Integration. Case Study of a Process Flow sheet- Estimation of Environmental Fates of Emissions and Wastes.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the basic principles of Green chemistry.

CO2: Understand the major environmental issue.

CO3: Understand the pollution prevention concepts and their environmental risks.

CO4: Understand the design concept for green chemistry.

CO5: Understand the procedure for estimating environmental cost.

CO6: Understand the basic concept behind product life cycle.

TEXT 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.

REFERENCES

1. Mukesh Doble and Anil Kumar Kruthiventi, Green Chemistry and Engineering, Elsevier, Burlington, USA, 2007.

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	Understand the basic principles of Green chemistry.	3	2	3	2	2	-	2	1	1	1	1	1	1	2	2
CO2	Understand the major environmental issue.	3	2	3	2	3	1	2	2	3	2	2	1	3	2	2
CO3	Understand the pollution prevention concepts and their environmental risks.	3	3	3	2	3	1	3	3	3	2	2	2	2	3	3
CO4	Understand the design concept for green chemistry.	-	2	-	3	-	3	-	1	-	1	-	-	-	2	2
CO5	Understand the procedure for estimating environmental cost.	2	2	2	2	2	1	2	2	2	2	2	2	2	3	3
CO6	Understand the basic concept behind product life cycle.	1	3	3	2	3	1	2	2	2	2	2	2	2	3	3
Over all		3	2	3	2	3	1	2	2	2	2	2	2	2	3	3

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

CL5024 **ENVIRONMENTAL NANOTECHNOLOGY**

	L	T	P	C
OBJECTIVE	**3**	**0**	**0**	**3**

This course covers the importance of all different aspects and effects of environmental nanotechnology.

UNIT I **9**

Basic concepts of Nanoscience and Nanotechnology – Quantum wire – Quantum well – Quantum dot – nano wires-nano rods-fullerenes – Graphene – Carbon nanotubes . Introduction to Potential uses of nanomaterials in environmental, energy and biomedical field.

UNIT II **9**

Preparation of nano scale metal oxides, metals, CNT, functionalized nano porous materials, nano composite, polymer ceramic nano composites, Material processing by -Chemical vapour deposition, sol gel, sonochemical, microwave, solvothermal, plasma, pulsed laser abalation, magnetron sputtering, electrospinning.

UNIT III **9**

Principle of AFM, STM, SEM, TEM, XRD, ESCA, IR & Raman, UV-DRS, of nanomaterials for structural & chemical nature.

UNIT IV **9**

Nanoparticles in the Environment; Nanoparticles in Mammalian Systems; Health Threats; Toxicological Studies and Toxicity of Manufactured CNTs- case study; Toxicity of CNTs and Occupational Exposure Risk; Toxicity of MWCNTs/SWCNTs and Impact on Environmental Health.

UNIT V **9**

Gas sensors, microfludics, catalytic and photocatalyic applications, doping of metal oxides to nano materials, Nonmaterials for wastewater treatment, nanomaterials as adsorbents, membrane process. Naomaterial for energy storage applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the basic concept of nanotechnology and their applications

CO2: Understand the various preparation methods of nano materials.

CO3: Understand the various instrumental analysis of nano materials.

CO4: Understand the effect of nano materials to human health.

CO5: Understand the nano materials for wastewater treatment applications.

CO6: Understand the nano materials for energy storage applications.

REFERENCES

1. Environmental applications of nanomaterials-Synthesis, Sorbents and Sensors, edited by Glen E Fryxell and Guozhong Cao, worldscibooks, UK
2. Environmental nanotechnology, Mark Wisener, JeoYuesBolteru, 2007, McGraw Hill.
3. The Chemistry of Nanomaterials, Sysnthesis, Properties and applications. Edited by C.N.R.Rao. Mullller, A.K.Cheetham Copyright 8 2004 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim

4. Handbook of Nanotechnology, Edi-Bharat Bhushan, Springer, 2004.
5. Pradeep T., “A Textbook of Nanoscience and Nanotechnology”, Tata McGraw Hill Education Pvt. Ltd., 2012.
6. Mark. R. Weisner and Jean-Yves Bottero —Environmental Nanotechnology applications and impact of nanomaterial, The McGraw-Hill Companies (2007).

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO7	PO8	PO9	PO1 0	PO1 1	PO1 2	PS O1	PS O2	PS O3
CO1	Understand the basic concept of nanotechnology and their applications	3	1	2	2	2	-	-	-	-	-	-	-	-	-	-
CO2	Understand the various preparation methods of nano materials.	3	1	2	2	2	-	-	-	-	-	-	-	-	-	-
CO3	Understand the various instrumental analysis of nano materials.	3	1	2	2	3	1	1	-	-	-	-	-	-	-	-
CO4	Understand the effect of nano materials to human health.	1	1	2	2		1	1	1	-	-	-	-	-	-	-
CO5	Understand the nano materials for wastewater treatment applications.	3	1	2	2	-	1	1	3	-	-	-	-	-	-	-
CO6	Understand the nano materials for energy storage applications.	1	1	1	2	2	2	2	1	-	-	-	-	-	-	-
Overal l		3	1	2	3	2	2	2		-	-	-	-	-	-	-

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

EV5002 **ENVIRONMENTAL SUSTAINABILITY**

L	T	P	C
3	0	0	3

OBJECTIVE

- Students will gain knowledge about 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, 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, 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**

Development, Poverty, and the Environment, Visions of the Future.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the knowledge of Valuing the Environment and Externalities to Environmental Problems.

CO2: Defining the concept of Sustainable Development

CO3: Understand the knowledge of Biodiversity and air pollution.

CO4: Understand the knowledge of water pollution and its hazards.

CO5: Understand the Visions of the Future: Development, Poverty, and the Environment.

TEXT 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.

REFERENCES

1. Tom Tietenberg, Environmental economics and policy 6th Edition, Pearson Education, 2010.
2. Stephen Doven, Environment and Sustainability Policy :Creation, Implementation, Evaluation, The Federation Press, 2005.

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Understand the knowledge of Valuing the Environment and Externalities to Environmental Problems.	2	2	2	3	2	2	2	2	3	2	3	2	2	2	2
CO2	Defining the concept of Sustainable Development	2	3	2	3	2	1	2	3	2	2	2	3	3	3	2
CO3	Understand the knowledge of Biodiversity and air pollution.	3	2	3	3	3	2	1	2	2	1	3	3	2	3	2
CO4	Understand the knowledge of water pollution and its hazards.	2	2	2	2	2	1	2	3	2	2	3	2	2	3	2
CO5	Understand the Visions of the Future: Development, Poverty, and the Environment.	2	3	3	3	2	3	3	3	3	3	3	3	2	3	2
Over all		3	3	2	2	1	2	3	3	2	2	3	2	2	2	3

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

EV5003 **ENVIRONMENTAL RISK ASSESSMENT**

L	T	P	C
3	0	0	3

OBJECTIVES:

- To develop a basic understanding of environmental health and risk assessment and its role within the risk management process.
- To learn about different risk assessment formats and their use in environmental health studies
- To learn about the different models for environmental risk assessment studies.

UNIT I **9**

Introduction to environmental risk assessment and available methodologies, quantitative risk assessment, Risk assessment steps, rapid risk analysis - comprehensive risk analysis – identification, evaluation and control of risk

UNIT II **9**

Hazard identification and control, Hazard assessment (consequence analysis), probabilistic hazard assessment (Fault tree analysis)

UNIT III **9**

Overall risk contours for different failure scenarios – disaster management plan –emergency planning – onsite and offsite emergency planning, risk management ISO 14000

UNIT IV **9**

Safety measures design in process operations. Accidents modeling – release modeling, toxic release and dispersion modeling, fire and explosion modeling.

UNIT V **9**

Past accident analysis: Flux borough – Mexico – Bhopal analysis. Government policies to manage environmental risk, , EMS models –case studies – marketing terminal, gas processing complex.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the concept of environmental risk assessment

CO2: Understand Hazard identification and control

CO3: Understand disaster management plan

CO4: Understand Safety measures design in process operations.

CO5: Understand the concept of accidents modeling

CO6: Government policies to manage environmental risk

REFERENCES

1. Crowl,D.A and Louvar,J.F., Chemical process safety; Fundamentals with applications, Prentice Hall publication inc., 2002.
2. Houstan,H.B., Process safety analysis, Gulf publishing company, 1997

Course Articulation Matrix:

Course outcomes	Statements	Program Outcomes														
		PO 1	PO 2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Understand the concept of environmental risk assessment	3	2	2	1	1	-	-	-	2	1	-	1	2	1	1
CO2	Understand Hazard identification and control	3	2	2	2	-	-	-	-	2	1	-	1	2	2	2
CO3	Understand disaster management plan	3	1	1	1	-	-	1	2	-	-	-	1	2	2	2
CO4	Understand Safety measures design in process operations.	3	1	2	2	-	-	-	-	1	-	-	2	1	1	1
CO5	Understand the concept of accidents modeling	1	1	2	-	2	1	1	1	-	-	1	1	2	2	2
CO6	Government policies to manage environmental risk	1	1	2	-	2	-	-	-	-	-	-	-	2	2	2
Over all		3	1	2	2	1	1	1	1	1	1	1	2	2	2	2

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

EV5004 **SOIL REMEDIATION TECHNOLOGIES**

	L	T	P	C
OBJECTIVE	**3**	**0**	**0**	**3**

- The objective of the course is to acquaint the students with current techniques for soil remediation.

UNIT I Introduction **8**

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 – organic geochemistry – 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 **10**

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 **8**

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 situ thermal treatments - soil vapour extraction thermally enhanced vitrification

UNIT V EX SITU TREATMENTS **10**

Ex situ physical/chemical treatments-chemical extraction-solar detoxification - chemical reduction/ oxidation- soil washing solidification/stabilization- soil vapour extraction; ex situ thermal treatment - shot gas decontamination thermal desorption plasm arc incineration pyrolysis vitrification

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Characterize the soil and classify them.

CO2: Understand many of the basic concepts of pollution, the effects of environmental contamination and the various remediation technologies which may be employed

CO3: be aware of contamination and degradation caused by various types of urban, industrial and agricultural development

CO4: Will know the transport processes in soil

CO5: Will be familiar with remediation technologies

CO6: Will be able to identify appropriate technology of soil contamination

TEXT 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

REFERENCES

1. Calvin Rose, An Introduction To The Environmental Physics Of Soil, Water And Water Sheds, Cambridge University Press, 2004.
2. Paul Nathanail C. And Paul Bardos R., Reclamation Of Contaminated Land, John Wiley & Sons Limited, 2004.
3. William J. Deutsch, Groundwater Geochemistry: Fundamentals And Applications To Contamination, Lewis Publishers, 1997

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Characterize the soil and classify them.	-	1	1	1	1	2	2	1	2	2	2	2	2	-	-
CO2	Understand many of the basic concepts of pollution, the effects of environmental contamination and the various remediation technologies which may be employed	-	-	1	1	2	-	1	-	1	-	-	2	-	-	-
CO3	be aware of contamination and degradation caused by various types of urban, industrial and agricultural development	-	-	-	2	1	-	2	-	1	-	2	2	-	-	-
CO4	Will know the transport processes in soil	-	-	-	2	2	-	1	-	1	-	-	1	-	2	2
CO5	Will be familiar with remediation technologies	-	1	-	-	1	-	1	-	1	2	-	-	-	-	-
CO6	Will be able to identify appropriate technology of soil contamination	-	1	1	-	1	2	2	1	1	2	-	1	-	2	2
Over all		-	1	1	2	1	2	2	1	1	2	2	2	2	2	2

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

CL5025 **ENVIRONMENT HEALTH AND SAFETY IN INDUSTRIES**

L	T	P	C
3	0	0	3

OBJECTIVE

- Students will gain knowledge about occupational health, industrial hygiene, accident prevention techniques and to train them in risk assessment and management.

UNIT I INTRODUCTION **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. Role of personal protective equipment and the selection criteria. 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. Contingency arrangements for events of serious and imminent danger.

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. Factors to be considered in the development of effective training programmes. Principles and methods of effective training. Feedback and evaluation mechanism.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to,

CO1: Learn the safety acts, regulations and initiatives.

CO2: Understand the insights of hazards and control measures.

CO3: Study the work place safety and safety systems.

CO4: Appreciate the need of accessing risks.

CO5: Understand the Procedure of investigating accidents.

CO6: Learn the importance of education and training on safety management.

TEXT 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.

REFERENCES

1. Bill Taylor , 'Effective Environmental, Health, and Safety Management Using the Team Approach', Culinary and Hospitality Industry Publications Services 2005.
2. Raghavan, K.V and A.A Khan, Methodologies in Hazard Identification and Risk Assessment, Manual by CLRI., Dec, 1990.

Course Articulation Matrix:

Course outcomes	Statements	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	Learn the safety acts, regulations and initiatives.	3	2	3	2	2	3	3	3	3	3	3	2	3	3	3
CO2	Understand the insights of hazards and control measures.	3	3	3	2	2	3	3	3	3	3	3	2	3	3	3
CO3	Study the work place safety and safety systems.	3	3	3	2	2	3	3	3	3	3	3	2	3	3	3
CO4	Appreciate the need of accessing risks.	3	3	3	2	2	3	3	3	3	3	3	2	3	3	3
CO5	Understand the Procedure of investigating accidents.	3	3	3	2	2	3	3	3	3	3	3	2	3	3	3
CO6	Learn the importance of education and training on safety management.	3	3	3	2	2	3	3	3	3	3	3	2	3	3	3
Over all		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

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

CL5026 **INDUSTRIAL INSTRUMENTATION**

	L	T	P	C
OBJECTIVE	**3**	**0**	**0**	**3**

- To enable Students to have knowledge on how to measure process variables, analytical Instrumentation and automatic process controls.

UNIT I **5**

Introduction – Variables, Units & standards of measurement, Measurement terms –characteristic. Data Analysis.

UNIT II **12**

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 **12**

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 analysers, 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 **9**

Fundamentals of Automatic process control – Control algorithms-Automatic controllers – Electronic controllers -Electric controllers (Traditional) - Hydraulic controllers – Fluidics - Programmable controllers.

UNIT V **7**

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. **TOTAL: 45 PERIODS**

COURSE OUTCOMES:

The students will be able to

CO1: Understand different process variables and their measurement units.

CO2: Understand the principle and working of various process variable measuring instruments.

CO3: Understand the principle, working and range of various analytical instruments

CO4: Understand the principle and working of various gas analysis instruments.

CO5: Understand the role of controller in industrial instrumentation.

CO6: Understand the electronic, pneumatic sensors for process variable measurement.

REFERENCES

1. Fribance, “Industrial Instrumentation Fundamentals” ,Mc Graw Hill Co. Inc. 1985
2. Eckman D.P. “Industrial Instrumentation”, Wiley Eastern Ltd., 1989.
3. Considine D M and Considine G D “Process Instruments Controls” Handbook 3rd Edition , McGraw – Hill Book Co., NY, 1990.
4. Scborg D E,.Edgar T.F and Mellichamp D.A, “Process Dynamics and Control” John Wiley 1989.
5. Ernest Doebelin, Measurement systems, McGraw – Hill Book, Co., NY, 1975.
6. Astrom K.J., Bjon wittenmark, Computer controlled systems, Prentice- Hall of India, New Delhi 1994.
7. Cartis Johnson, Process Control Instrumentation Technology, Prentice-Hall of India, New Delhi 1993.

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	Understand different process variables and their measurement units.	1	1	-	2	1	3	1	2	2	1	1	-	2	1	1
CO2	Understand the principle and working of various process variable measuring instruments.	1	1	1	2	2	3	1	3	2	1	2	1	2	1	1
CO3	Understand the principle, working and range of various analytical instruments	1	2	1	2	2	3	1	3	3	1	3	2	2	1	1
CO4	Understand the principle and working of various gas analysis instruments.	1	2	1	2	1	3	1	3	2	1	3	2	2	1	1
CO5	Understand the role of controller in industrial instrumentation.	1	2	1	1	2	3	2	2	2	1	2	1	2	1	1
CO6	Understand the electronic, pneumatic sensors for process variable measurement.	1	2	1	2	2	3	1	3	3	1	3	2	2	2	2
Over all		1	2	1	2	2	3	1	3	3	1	3	2	3	1	1

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

CL5072 **DESIGN OF EXPERIMENTS**

L	T	P	C
3	0	0	3

OBJECTIVE

- To introduce the student to the principles and methods of statistical analysis of designed experiments, understand hypothesis testing, perform factorial designs for experiments and model using response surface techniques.

UNIT I **9**

Introduction: Strategy of experimentation, basic principles, guidelines for designing experiments. Simple Comparative Experiments: Basic statistical concepts, sampling and sampling distribution, inferences about the differences in means: Hypothesis testing, Choice of samples size, Confidence intervals, Randomized and paired comparison design.

UNIT II **9**

Experiments with Single Factor; An example, The analysis of variance, Analysis of the fixed effect model, Model adequacy checking, Practical interpretation of results, Sample computer output, Determining sample size, Discovering dispersion effect, The regression approach to the analysis of variance, Non parameteric methods in the analysis of variance, Problems.

UNIT III **9**

Design of Experiments: Introduction, Basic principles: Randomization, Replication, Blocking, Degrees of freedom, Confounding, Design resolution, Metrology considerations for industrial designed experiments, Selection of quality characteristics for industrial experiments. Parameter Estimation

UNIT IV **9**

Response Surface Methods: Introduction, The methods of steepest ascent, Analysis of a second order response surface, Experimental designs for fitting response surfaces: Designs for fitting the first-order model, Designs for fitting the second-order model, Blocking in response surface Computer-generated (Optimal) designs, Mixture experiments, Evolutionary operation, Robust design, Problems

UNIT V **9**

Design and Analysis: Introduction, Preliminary examination of subject of research, Screening experiments: Preliminary ranking of the factors, active screening experiment-method of random balance, active screening experiment Plackett-Burman designs, Completely randomized block design, Latin squares, Graeco-Latin Square, Youdens Squares, Basic experiment-mathematical modeling, Statistical Analysis, Experimental optimization of research subject: Problem of optimization, Gradient optimization methods, Nongradient methods of optimization, Simplex sum rotatable design, Canonical analysis of the response surface, Examples of complex optimizations.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand sampling and sampling distribution

CO2: Apply Hypothesis testing with different confidence intervals

CO3: Perform ANOVA and regression analysis

CO4: Perform statistically designed experiments with and without blocking

CO5: Model the given data using Response Surface Methodology

CO6: Perform optimized experimentation like Plackett Burman design, Youden square

TEXT BOOKS

1. Lazic Z. R., Design of Experiments in Chemical Engineering, A Practical Guide, Wiley, 2005.
2. Antony J., Design of Experiments for Engineers and Scientists, Butterworth Heinemann, 2004.
3. Montgomery D. C., Design and Analysis of Experiments, Wiley, 5 th Edition, 2010.

REFERENCES

1. Doebelin E. O., Engineering Experimentation: Planning, Execution, Reporting, McGraw-Hill, 1995
2. Anderson, V. L., & McLean, R. A. (2018). *Design of experiments: a realistic approach*. Routledge.

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	Understand sampling and sampling distribution	1	1	2	3	2	-	2	-	1	1	1	1	2	3	2
CO2	Apply Hypothesis testing with different confidence intervals	1	1	2	1	2	-	2	-	1	1	1	1	3	3	2
CO3	Perform ANOVA and regression analysis	1	1	2	3	3	-	2	-	1	1	1	1	3	3	2
CO4	Perform statistically designed experiments with and without blocking	1	1	2	3	3	-	2	-	1	1	1	1	3	2	2
CO5	Model the given data using Response Surface Methodology	1	1	2	3	3	-	2	-	1	1	1	1	2	1	2
CO6	Perform optimized experimentation like Plackett Burman design, Youden square	1	1	2	3	3	-	2	-	1	1	1	1	3	3	2
Over all		1	1	2	3	3	-	2	-	1	1	1	1	3	3	2

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

CL5027 **RISK ANAYSIS AND HAZOP**

	L	T	P	C
OBJECTIVE	**3**	**0**	**0**	**3**

Students will gain knowledge about risks involved in working premises and to avoid accidents using prevention methods.

UNIT I **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 **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

UNIT III **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 **9**

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

UNIT V **9**

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the knowledge of types of risks arising in working environment

CO2: Defining the concept of explosion and its effects

CO3: Understand the knowledge of disaster management.

CO4: Understand the knowledge of checklist and audits

CO5: Will be familiar with hazop and its consequences.

CO6: Will be able to create hazard free working premises

TEXT BOOKS

1. Crowl,D.A and Louvar,J.F., Chemical process saftery; Fundamentals with applications, prentice hall publication inc., 2002.
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.

REFERENCES

1. Khan,F.I and Abbasi,S.A., Risk assessment of chemical process industries; Emerging technologies, Discovery publishing house, New Delhi, 1999.
2. Houstan,H.B., Process safety analysis, Gulf publishing company, 1997.

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO 1	P O2	P O3	P O4	P O5	P O6	P O7	P O8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Understand the knowledge of types of risks arising in working environment	3	2	3	3	3	2	2	3	3	3	2	2	3	2	2
CO2	Defining the concept of explosion and its effects	1	-	2	2	3	2	3	-	-	2	2	3	2	3	3
CO3	Understand the knowledge of disaster management.	3	-	3	-	-	2	3	2	2	-	-	2	-	-	-
CO4	Understand the knowledge of checklist and audits	2	-	-	-	2	2	2	3	2	3	2	2	3	3	3
CO5	Will be familiar with hazop and its consequences.	3	-	3	-	2	2	3	2	3	-	2	2	3	3	3
CO6	Will be able to create hazard free working premises	1	3	2	3	2	2	3	1	1	2	1	2	2	2	2
Over all		3	3	3	3	3	2	3	3	3	3	2	3	3	3	3

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

EV5005 **ENVIRONMENTAL MANAGEMENT**

	L	T	P	C
OBJECTIVE	**3**	**0**	**0**	**3**

- To make the students aware of environmental legislation and strategies to control pollution,

UNIT I **9**

Environmental legislation and strategies to control pollution, Environmental Legislations in India, Standards and Guidelines, Pollution prevention policy

UNIT II **9**

Water (Prevention and control of Pollution) Act 1974, Air (Prevention and Control of Pollution)Act 1981, Environmental Protection Act 1986, Hazardous Waste management Rules Standards for discharge of treated liquid effluent into water bodies, standards for disposal of air emissions into atmosphere.

UNIT III **9**

Factory Act 1987 of India, Occupational health and safety requirements and standards of ILO, Compliance of rules and guidelines of Factory Act applicable to industries, National and international certification scheme.

UNIT IV **9**

Principles of Environmental impact assessment and audit guidelines and legislature requirements for setting of industrial units in estates/complex. Environmental Pollution monitoring and measurement. Preparatory procedures for EIA study, Evaluation of quality standards of air, water and land environment.

UNIT V **9**

Sampling and analysis techniques, Data interpretations and relationships for the design of treatment facilities , Principles of Environmental Auditing, Cleaner Technologies in Industrial Processes and evaluation of processes Monitoring of, liquid and solid waste management. Case studies: Life cycle assessment

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand environmental legislation and strategies to control pollution

CO2: Understand standards, guidelines and pollution prevention policy

CO3: Understand the standards for discharge of treated liquid effluent into water bodies and standards for disposal of air emissions

CO4: Understand occupational health and safety requirements

CO5: Understand environmental pollution monitoring and measurement.

CO6: Understand the principles of environmental impact assessment legislature requirements for industrial units in estates/complex

REFERENCES

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. UNEP/IED Technical Report Serial No.2., Environmental Auditing, 1990.
6. B.N. Lohani, Environmental quality management, South Asian Publishers, New Delhi, 1984.

Course Articulation Matrix:

Course outcomes	Statements	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Understand environmental legislation and strategies to control pollution	3	1	1	1	1	-	-	-	-	-	1	1	1	1	1
CO2	Understand standards, guidelines and pollution prevention policy	2	1	1	1	1	1	-	3	2	1	-	-	1	1	1
CO3	Understand the standards for discharge of treated liquid effluent into water bodies and standards for disposal of air emissions	3	1	1	1	1	1	1	2	-	1	-	-	1	1	1
CO4	Understand occupational health and safety requirements	2	1	1	1	-	2	2	1	1	-	1	1	2	2	2
CO5	Understand environmental pollution monitoring and measurement.	3	2	1	1	1	-	2	2	2	-	-	-	2	2	2
CO6	Understand the principles of environmental impact assessment legislature requirements for industrial units in estates/complex	3	2	1	1	-	-	2	1	1	1	-	1	1	1	1
Over all		3	2	1	1	1	1	2	2	1	1	1	2	2	2	2

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

EV5006 PRINCIPLES OF CLEANER PRODUCTION

	L	T	P	C
OBJECTIVE	**3**	**0**	**0**	**3**

- To Introduce The Importance, And Different Approaches Of Cleaner Production In Industries And To Impart Knowledge On Environmental Management Tools Applying Cleaner Production Principle.

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.

UNIT II CLEANER PRODUCTION 9

Definition – Methodology – Historical Evolution – Benefits – Promotion – Barriers – Role Of Industry, Government And Institutions – Environmental Management Hierarchy – Relation Of CP And EMS – Integrated Prevention And Pollution Limitation – Best Available Technology Concept (BAT) – Internet Information & Other CP Resources

UNIT III QUALITATIVE PHASE BEHAVIOUR OF HYDROC CLEANER 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 – 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:

The students will be able to

CO1: Ability to describe the evolution of corporate environmental management strategies.

CO2: Ability to describe cleaner production measures applicable to different industries

CO3: Ability to conduct energy and material balances for processes as part of a cleaner production assessment.

CO4: Understanding of strategies and technologies for a cleaner industrial production.

CO5: Understanding the relation to the concept of sustainable development.

CO6: To enhance the knowledge on environmental sustainability.

TEXT BOOKS

1. Paul L. Bishop, „Pollution Prevention: Fundamentals And Practice", McGraw Hill International, 2000.
2. Prasad Modak C. Visvanathan And Mandar Parasnis , „Cleaner Production Audit", Environmental System Reviews, No.38, Asian Institute Of Technology, Bangkok, 1995.

REFERENCES

1. World Bank Group "Pollution Prevention And Abatement Handbook – Towards Cleaner Production", World Bank And UNEP, Washington D. C., 1998.
2. Prausnitz, J.M., Lichtenthaler R.M. and Azevedo, E.G., Molecular thermodynamics of fluid-phase Equilibria, 3rd Edn, Prentice Hall Inc., New Jersey, 1999

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Ability to describe the evolution of corporate environmental management strategies.	-	-	-	2	-	1	-	1	-	-	-	2	2	-	-
CO2	Ability to describe cleaner production measures applicable to different industries	-	-	-	-	-	-	-	1	-	-	-	3	2	1	1
CO3	Ability to conduct energy and material balances for processes as part of a cleaner production assessment.	-	-	-	2	-	-	2	1	-	2	-	1	-	-	-
CO4	Understanding of strategies and technologies for a cleaner industrial production.	-	-	2	3	-	1	2	1	-	-	-	-	-	-	-
CO5	Understanding the relation to the concept of sustainable development.	-	-	3	3	-	-	3	-	-	3	-	1	3	-	-
CO6	To enhance the knowledge on environmental sustainability.	-	-	3	1	-	3	2	-	-	-	-	1	-	-	-
Over all		-	-	3	2	-	1	2	1	-	2	-	1	2	1	1

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

CL5028 **ENVIRONMENTAL BIOTECHNOLOGY**

L	T	P	C
3	0	0	3

OBJECTIVE

- The main objective of this course is to impart students an understanding of pollution of environment by air, water and soil responsible for degradation of natural resources and degradation of biodiversity.

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 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

UNIT III 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 fertilizers, Vermiculture Biotechnology: vermiculture for sustainable agriculture and solid waste management.

UNIT IV 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 - metals. Mechanisms of detoxification, oxidation reactions, dehalogenation - biotransformation of metals. Microbial cell/enzyme technology – adapted microorganisms - biological removal of nutrients – microalgal biotechnology

UNIT V 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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Apply the concept of environmental biotechnology and the different types of microbes used

CO2: Classify the different pollutants and identify the appropriate control strategy

CO3: Understand the nature of solid waste pollutants and recognize their remediation through environmental biotechnology techniques

CO4: Gain knowledge on the bioremediation strategies for decontamination and detoxification of environmental systems

CO5: Acquire a knowledge on the basics of DNA, their impact on environment and the ethics of microbial technology

CO6: Get to know the overview of important environmental biotechnologies involved in biotransformation of pollutants and generation of energy and understand the role of environmental biotechnologist and their responsibilities to the environment

REFERENCES

1. Fulker M.H. Environmental Biotechnology, CRC Press, 2010.
2. Wainwright, M, An Introduction to Environmental Biotechnology, 1999.
3. Martin, A.M., Biological Degradation of Wastes, Elsevier Appl. Science, New York,1991
4. Gray, S.S., Fox, R and James W. Blackburn Environmental Biotechnology for Waste Treatment, Plenum Press, New York 1991.
5. 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.
6. Old, R.W., and. Primrose, S.B., Principles of Gene Manipulation (3rd Ed.), BlackwellSci. Pub, Cambridge, 1985

Course Articulation Matrix

Course Outcomes	Statements	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	Apply the concept of environmental biotechnology and the different types of microbes used	-	-	2	1	-	-	-	-	1	1	1	1	2	1	1
CO2	Classify the different pollutants and identify the appropriate control strategy	-	-	2	1	2	2	-	-	1	3	2	1	2	1	1
CO3	Understand the nature of solid waste pollutants and recognize their remediation through environmental biotechnology techniques	-	-	2	1	-	1	-	-	2	2	2	1	3	1	1
CO4	Gain knowledge on the bioremediation strategies for decontamination and detoxification of environmental systems	-	-	3	1	3	2	-	-	2	2	1	1	1	-	-
CO5	Acquire a knowledge on the basics of DNA, their impact on environment and the ethics of microbial technology	-	-	3	2	1	1	-	-	1	3	3	1	2	3	3
CO6	Get to know the overview of important environmental biotechnologies involved in biotransformation of pollutants and generation of energy and understand the role of environmental biotechnologist and their responsibilities to the environment	-	-	3	3	1	2	1	-	1	3	3	3	3	3	3
Over all		-	-	3	2	2	2	1	-	2	3	2	2	3	2	2

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

EV5007 WASTE MANAGEMENT AND ENERGY RECOVERY

	L	T	P	C
OBJECTIVE	**3**	**0**	**0**	**3**

The objective of the course is to provide insights into waste management options by reducing the waste destined for disposal and encouraging the use of waste as a resource for alternate energy production.

UNIT I **9**

Introduction The Principles of Waste Management and Waste Utilization. Waste Management Hierarchy and 3R Principle of Reduce, Reuse and Recycle. Waste as a Resource and Alternate Energy source. Waste Sources & Characterization Waste production in different sectors such as domestic, industrial, agriculture, postconsumer, waste etc. Classification of waste – agro based, forest residues, domestic waste, industrial waste (hazardous and non-hazardous). Characterization of waste for energy utilization. Waste Selection criteria.

UNIT II **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 III **12**

Waste to Energy Options Landfill gas, collection and recovery. Refuse Derived Fuel (RDF) –Energy from Plastic Wastes – Non-recyclable plastic wastes for energy recovery. Energy Recovery from wastes and optimization of its use, benchmarking and standardization. Case Studies – 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

UNIT IV Hazardous waste management: **9**

Hazardous waste – definition - potential sources - waste sources by industry – impacts –waste control methods – transportation regulations - risk assessment – remediation technologies – Private public paternership – Government initiatives. Ultimate disposal - Landfill – classification – site selection parameters – design aspects – Leachate control – environmental monitoring system for Land Fill Gases.

UNIT V **6**

Waste To Energy & Environmental Implications Environmental standards for Waste to Energy Plant operations and gas clean-up. Savings on non-renewable fuel resources.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will

CO1: understand the concept of Waste to Energy

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

CO3: Learn about the best available technologies for waste to energy.

CO4: Be able analyze case studies for understanding success and failures.

CO5: Develop the skills in the decision making process.

CO6: Know the various sources of waste generation its potential for energy production.

TEXT 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

REFERENCES

1. Stanley E. Manahan. Hazardous Waste Chemistry, Toxicology and Treatment, Lewis Publishers, Chelsea, Michigan, 1990
2. Parker, Colin and Roberts, Energy from Waste – An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985.
3. ManojDatta, Waste Disposal in Engineered Landfills, Narosa Publishing House, 1997.

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	understand the concept of Waste to Energy	-	2	2	1	2	-	-	-	-	1	-	2	1	2	2
CO2	Be capable of linking legal, technical and management principles for production of energy form waste.	-	2	2	1	2	-	-	-	1	-	-	2	1	2	2
CO3	Learn about the best available technologies for waste to energy.	-	2	2	-	2	1	1	-	-	-	-	2	1	2	2
CO4	Be able analyze case studies for understanding success and failures.	-	2	2	-	3	1	1	1	1	1	1	1	1	2	2
CO5	Develop the skills in the decision making process.	-	2	1	-	2	1	1	1	1	-	-	1	1	2	2
CO6	Know the various sources of waste generation its potential for energy production.	-	2	1	-	2	2	2	1	-	1	-	2	1	2	2
Over all		-	2	2	1	2	2	2	1	1	-	1	2	1	2	2

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

CL5029 ADVANCED OXIDATION PROCESSES AND TECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVE

Students will aware of the techniques used for removing contaminants and various technology to control emissions

UNIT I **9**

Introduction to AOP, fundamentals of AOPs for water and wastewater treatment.

UNIT II **9**

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

UNIT III **9**

Photochemistry, photolysis, photocatalytic reactions, mechanism of photocatalytic reaction, fundamentals of semiconductor photocatalyis, types of photocatalyst. Fenton processes: homo and heterogeneous process, effect of system composition and process, identification of degradation products.

UNIT IV **9**

AOP processes for water and wastewater treatment, Photoelectrocatalysis process: photooxidation reactions, photo-initiated oxidations, photomineraliztion of organic matter in water and air, aqueous systems, sonocatalysis, heterogeneous and homogeneous photocatalysis and kinetic studies, biodegradability and toxicological studies.

UNIT V **9**

Application of AOPs for VOC reduction, biologically toxic or non-degradable and odour treatment, case studies – textile, pharmaceutical and petroleum and petrochemical industries.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the fundamentals of AOP.

CO2: Understand the various AOP methods and its principle.

CO3: Understand the basic mechanism of AOP reaction.

CO4: Understand the fundamentals of semiconductor photolysis.

CO5: Understand the various AOP process for treating organic matter in water.

CO6: Application of AOP in treating non degradable waste.

TEXT 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.

REFERENCES

1. Vincenzo Belgiorno, Vincenzo Naddeo and Luigi Rizzo, Water, wastewater and soil treatment by Advanced Oxidation Processes (AOP), Lulu Enterprises, 2011.

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Understand the fundamentals of AOP.	2	2	2	3	2	2	2	2	3	2	3	2	2	2	2
CO2	Understand the various AOP methods and its principle.	2	3	2	3	2	1	2	3	2	2	2	3	3	3	2
CO3	Understand the basic mechanism of AOP reaction.	3	2	3	3	3	2	1	2	2	1	3	3	2	3	2
CO4	Understand the fundamentals of semiconductor photolysis.	2	2	2	2	2	1	2	3	2	2	3	2	2	3	2
CO5	Understand the various AOP process for treating organic matter in water.	2	3	3	3	2	3	3	3	3	3	3	3	2	3	2
CO6	Application of AOP in treating non degradable waste.	3	3	2	2	1	2	3	3	2	2	3	2	2	2	3
Over all		2	3	2	3	2	2	2	3	2	2	3	3	2	3	2

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

CL5030 **ELECTROCHEMICAL ENVIRONMENTAL TECHNOLOGY**

L	T	P	C
3	0	0	3

OBJECTIVE

- Students will learn different types of electrochemical reactors, wastewater characteristic, and Electrochemical techniques to treat the gas, liquid and soil pollutant.

UNIT I **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 **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 **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 **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 **9**

Materials for electrochemical treatment, electrodes used in different types of industries. Membrane assisted process, electro dialysis and electrochemical ion exchange process, electro osmosis. Membrane assisted electrochemical process for pollutant treatment, Electro winning process.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the Physical and chemical Characteristics of wastewater and their measurement.

CO2: Understand the electrochemical engineering concept to treat the industrial pollutants.

CO3: Understand the various pollutant treatment techniques.

CO4: Understand the various electrochemical reactors for pollutant treatment process.

CO5: Understand the photo electrochemical method for pollutant treatment.

CO6: Understand the membrane based electrochemical process for pollutant treatment.

REFERENCES

1. Rajeshwar, K. and Ibanez, J.G., Environmental Electrochemistry, Academic Pre, 1997.
2. Pletcher, D., and Walsh, F., Industrial Electrochemistry, 2 nd Edn., Chapman and Hall, 1990.
3. Scott, K., Electrochemical Process for Cleaner Technology, Academic Pres, 1990.
4. Kirkwood, R. C. And Longley, A.J., Clean Technology and Environment, Chapman & Hall,1995.

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Understand the Physical and chemical Characteristics of wastewater and their measurement.	3	1	1	2	1	1	-	-	-	-	1	-	3	-	-
CO2	Understand the electrochemical engineering concept to treat the industrial pollutants.	1	1	1	3	2	1	-	-	-	-	1	-	3	-	-
CO3	Understand the various pollutant treatment techniques.	1		1	2	3	1	-	-	-	-	1	-	3		-
CO4	Understand the various electrochemical reactors for pollutant treatment process.	1	1	1	1	2	3	-	-	-	-	1	- -	3	-	-
CO5	Understand the photo electrochemical method for pollutant treatment.	2	1	1	1	1	3	-	-	-	-	1	-	3	-	-
CO6	Understand the membrane based electrochemical process for pollutant treatment.	2	1	1	1	1	1	-	-	-	-	1	-	3	-	-
Over all		3	1	1	3	3	3	-	-	-	-	1	-	3	-	-

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

OPEN ELECTIVE COURSES (OEC)

OE5091 BUSINESS DATA ANALYTICS L T P C
3 0 0 3

OBJECTIVES:

- To understand the basics of business analytics and its life cycle.
- To gain knowledge about fundamental business analytics.
- To learn modeling for uncertainty and statistical inference.
- To understand analytics using Hadoop and Map Reduce frameworks.
- To acquire insight on other analytical frameworks.

UNIT I OVERVIEW OF BUSINESS ANALYTICS 9

Introduction – Drivers for Business Analytics – Applications of Business Analytics: Marketing and Sales, Human Resource, Healthcare, Product Design, Service Design, Customer Service and Support – Skills Required for a Business Analyst – Framework for Business Analytics Life Cycle for Business Analytics Process.

Suggested Activities:

- Case studies on applications involving business analytics.
- Converting real time decision making problems into hypothesis.
- Group discussion on entrepreneurial opportunities in Business Analytics.

Suggested Evaluation Methods:

- Assignment on business scenario and business analytical life cycle process.
- Group presentation on big data applications with societal need.
- Quiz on case studies.

UNIT II ESSENTIALS OF BUSINESS ANALYTICS 9

Descriptive Statistics – Using Data – Types of Data – Data Distribution Metrics: Frequency, Mean, Median, Mode, Range, Variance, Standard Deviation, Percentile, Quartile, z-Score, Covariance, Correlation – Data Visualization: Tables, Charts, Line Charts, Bar and Column Chart, Bubble Chart, Heat Map – Data Dashboards.

Suggested Activities:

- Solve numerical problems on basic statistics.
- Explore chart wizard in MS Excel Case using sample real time data for data visualization.
- Use R tool for data visualization.

Suggested Evaluation Methods:

- Assignment on descriptive analytics using benchmark data.
- Quiz on data visualization for univariate, bivariate data.

UNIT III MODELING UNCERTAINTY AND STATISTICAL INFERENCE 9

Modeling Uncertainty: Events and Probabilities – Conditional Probability – Random Variables – Discrete Probability Distributions – Continuous Probability Distribution – Statistical Inference: Data Sampling – Selecting a Sample – Point Estimation – Sampling Distributions – Interval Estimation – Hypothesis Testing.

Suggested Activities:

- Solving numerical problems in sampling, probability, probability distributions and hypothesis testing.
- Converting real time decision making problems into hypothesis.

Suggested Evaluation Methods:

- Assignments on hypothesis testing.
- Group presentation on real time applications involving data sampling and hypothesis testing.

- Quizzes on topics like sampling and probability.

UNIT IV ANALYTICS USING HADOOP AND MAPREDUCE FRAMEWORK 9

Introducing Hadoop– RDBMS versus Hadoop–Hadoop Overview – HDFS (Hadoop Distributed File System) – Processing Data with Hadoop– Introduction to MapReduce – Features of MapReduce – Algorithms Using Map-Reduce: Matrix-Vector Multiplication, Relational Algebra Operations, Grouping and Aggregation – Extensions to MapReduce.

Suggested Activities:

- Practical – Install and configure Hadoop.
- Practical – Use web based tools to monitor Hadoop setup.
- Practical – Design and develop MapReduce tasks for word count, searching involving text corpus etc.

Suggested Evaluation Methods:

- Evaluation of the practical implementations.
- Quizzes on topics like HDFS and extensions to MapReduce.

UNIT V OTHER DATA ANALYTICAL FRAMEWORKS 9

Overview of Application development Languages for Hadoop – PigLatin – Hive – Hive Query Language (HQL) – Introduction to Pentaho, JAQL – Introduction to Apache: Sqoop, Drill and Spark, Cloudera Impala – Introduction to NoSQL Databases – Hbase and MongoDB.

Suggested Activities:

- Practical – Installation of NoSQL database like MongoDB.
- Practical – Demonstration on Sharding in MongoDB.
- Practical – Install and run Pig
- Practical – Write PigLatin scripts to sort, group, join, project, and filter data.
- Design and develop algorithms to be executed in MapReduce involving numerical methods for analytics.

Suggested Evaluation Methods:

- Mini Project (Group) – Real time data collection, saving in NoSQL, implement analytical techniques using Map-Reduce Tasks and Result Projection.

TOTAL: 45 PERIODS

OUTCOMES:

On completion of the course, the student will be able to:

- Identify the real world business problems and model with analytical solutions.
- Solve analytical problem with relevant mathematics background knowledge.
- Convert any real world decision making problem to hypothesis and apply suitable statistical testing.
- Write and Demonstrate simple applications involving analytics using Hadoop and MapReduce
- Use open source frameworks for modeling and storing data.
- Apply suitable visualization technique using R for visualizing voluminous data.

REFERENCES:

1. VigneshPrajapati, “Big Data Analytics with R and Hadoop”, Packt Publishing, 2013.
2. Umesh R Hodeghatta, UmeshaNayak, “Business Analytics Using R – A Practical Approach”, Apress, 2017.
3. AnandRajaraman, Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press, 2012.
4. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson, “Essentials of Business Analytics”, Cengage Learning, second Edition, 2016.
5. U. Dinesh Kumar, “Business Analytics: The Science of Data-Driven Decision Making”, Wiley, 2017.
6. A. Ohri, “R for Business Analytics”, Springer, 2012
7. Rui Miguel Forte, “Mastering Predictive Analytics with R”, Packt Publication, 2015.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	2	3	1
CO2	2	1	1	2	1	1
CO3	1	1	2	3	3	1
CO4	2	2	1	2	1	1
CO5	1	1	2	2	1	1
CO6	1	1	1	3	2	1

OE5092 **INDUSTRIAL SAFETY** **LT P C**
3 0 0 3

OBJECTIVES:

- Summarize basics of industrial safety
- Describe fundamentals of maintenance engineering
- Explain wear and corrosion
- Illustrate fault tracing
- Identify preventive and periodic maintenance

UNIT I INTRODUCTION 9

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

UNIT II FUNDAMENTALS OF MAINTENANCE ENGINEERING 9

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT III WEAR AND CORROSION AND THEIR PREVENTION 9

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT IV FAULT TRACING 9

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

UNIT V PERIODIC AND PREVENTIVE MAINTENANCE 9

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

TOTAL: 45 PERIODS

OUTCOMES:

CO1: Ability to summarize basics of industrial safety
CO2: Ability to describe fundamentals of maintenance engineering
CO3: Ability to explain wear and corrosion
CO4: Ability to illustrate fault tracing
CO5: Ability to identify preventive and periodic maintenance

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Audels, Pump-hydraulic Compressors, Mcgrew Hill Publication, 1978.
2. Garg H P,Maintenance Engineering, S. Chand and Company,1987.
3. Hans F. Winterkorn ,Foundation Engineering Handbook, Chapman & Hall London,2013.
4. Higgins & Morrow , Maintenance Engineering Handbook,Eighth Edition,2008

OE5093 OPERATIONS RESEARCH LT P C
3 0 0 3

OBJECTIVES:

- Solve linear programming problem and solve using graphical method.
- Solve LPP using simplex method
- Solve transportation , assignment problems
- Solve project management problems
- Solve scheduling problems

UNIT I LINEAR PROGRAMMING 9

Introduction to Operations Research – assumptions of linear programming problems - Formulations of linear programming problem – Graphical method

UNIT II ADVANCES IN LINEAR PROGRAMMING 9

Solutions to LPP using simplex algorithm- Revised simplex method - primal dual relationships – Dual simplex algorithm - Sensitivity analysis

UNIT III NETWORK ANALYSIS – I 9

Transportation problems -Northwest corner rule, least cost method,Voges's approximation method - Assignment problem -Hungarian algorithm

UNIT IV NETWORK ANALYSIS – II 9

Shortest path problem: Dijkstra's algorithms, Floyds algorithm, systematic method -CPM/PERT

UNIT V NETWORK ANALYSIS – III 9

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models

TOTAL: 45 PERIODS

OUTCOMES:

CO1: To formulate linear programming problem and solve using graphical method.
CO2: To solve LPP using simplex method
CO3: To formulate and solve transportation, assignment problems
CO4: To solve project management problems
CO5: To solve scheduling problems

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010
2. Hitler Libermann, Operations Research: McGraw Hill Pub. 2009
3. Pant J C, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Pannerselvam, Operations Research: Prentice Hall of India 2010
5. Taha H A, Operations Research, An Introduction, PHI, 2008

OE5094 COST MANAGEMENTOF ENGINEERING PROJECTS L T P C
3 0 0 3

OBJECTIVES:

- Summarize the costing concepts and their role in decision making
- Infer the project management concepts and their various aspects in selection
- Interpret costing concepts with project execution
- Develop knowledge of costing techniques in service sector and various budgetary control techniques
- Illustrate with quantitative techniques in cost management

UNIT I INTRODUCTION TO COSTING CONCEPTS 9

Objectives of a Costing System; Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Creation of a Database for operational control.

UNIT II INTRODUCTION TO PROJECT MANAGEMENT 9

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities, Detailed Engineering activities, Pre project execution main clearances and documents, Project team: Role of each member,Importance Project site: Data required with significance, Project contracts.

UNIT III PROJECT EXECUTION AND COSTING CONCEPTS 9

Project execution Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis, Various decision-making problems, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing.

UNIT IV COSTING OF SERVICE SECTOR AND BUDGETERY CONTROL 9

Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis, Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets.

UNIT V QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT 9

Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory.

TOTAL: 45 PERIODS

OUTCOMES

CO1 – Understand the costing concepts and their role in decision making
CO2–Understand the project management concepts and their various aspects in selection
CO3–Interpret costing concepts with project execution
CO4–Gain knowledge of costing techniques in service sector and various budgetary control techniques
CO5 - Become familiar with quantitative techniques in cost management

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓		✓			✓	✓		✓	✓
CO2	✓	✓	✓		✓				✓		✓	✓
CO3	✓	✓	✓		✓	✓					✓	✓
CO4	✓	✓	✓		✓		✓				✓	✓
CO5	✓	✓	✓		✓	✓	✓				✓	✓

REFERENCES:

1. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher, 1991
2. Charles T. Horngren and George Foster, Advanced Management Accounting, 1988
3. Charles T. Horngren et al Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi, 2011
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting, 2003
5. Vohra N.D., Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd, 2007

OE5095 COMPOSITE MATERIALS L T P C
3 0 0 3

OBJECTIVES:

- Summarize the characteristics of composite materials and effect of reinforcement in composite materials.
- Identifythe various reinforcements used in composite materials.
- Compare the manufacturing process of metal matrix composites.
- Understand the manufacturing processes of polymer matrix composites.
- Analyze the strength of composite materials.

UNIT I INTRODUCTION 9

Definition – Classification and characteristics of Composite materials - Advantages and application of composites - Functional requirements of reinforcement and matrix - Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT II REINFORCEMENTS 9

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers - Properties and applications of whiskers, particle reinforcements - Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures - Isostrain and Isostress conditions.

UNIT III MANUFACTURING OF METAL MATRIX COMPOSITES 9

Casting – Solid State diffusion technique - Cladding – Hot isostatic pressing - Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving - Properties and applications.

UNIT IV MANUFACTURING OF POLYMER MATRIX COMPOSITES 9

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method –Filament winding method – Compression moulding – Reaction injection moulding - Properties and applications.

UNIT V STRENGTH 9

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TOTAL: 45 PERIODS

OUTCOMES:

- CO1 - Know the characteristics of composite materials and effect of reinforcement in composite materials.
- CO2 – Know the various reinforcements used in composite materials.
- CO3 – Understand the manufacturing processes of metal matrix composites.
- CO4 – Understand the manufacturing processes of polymer matrix composites.
- CO5 – Analyze the strength of composite materials.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		✓	✓	✓								
CO2		✓✓	✓	✓	✓						✓	
CO3			✓	✓	✓		✓				✓	
CO4			✓	✓	✓		✓				✓	
CO5				✓	✓		✓					

REFERENCES:

1. Cahn R.W. - Material Science and Technology – Vol 13 – Composites, VCH, WestGermany.
2. Callister, W.D Jr., Adapted by Balasubramaniam R, Materials Science and Engineering, An introduction, John Wiley & Sons, NY, Indian edition, 2007.
3. Chawla K.K., Composite Materials, 2013.
4. Lubin.G, Hand Book of Composite Materials, 2013.

OE5096 **WASTE TO ENERGY** **L T P C**
3 0 0 3

OBJECTIVES:

- Interpret the various types of wastes from which energy can be generated
- Develop knowledge on biomass pyrolysis process and its applications
- Develop knowledge on various types of biomass gasifiers and their operations
- Invent knowledge on biomass combustors and its applications on generating energy
- Summarize the principles of bio-energy systems and their features

UNITI INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE 9

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

UNITIIBIOMASS PYROLYSIS 9

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNITIII BIOMASS GASIFICATION 9

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNITIV BIOMASS COMBUSTION 9

Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNITV BIO ENERGY 9

Properties of biogas (Calorific value and composition), Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production -Urban waste to energy conversion - Biomass energy programme in India.

TOTAL: 45 PERIODS

OUTCOMES:

CO1 – Understand the various types of wastes from which energy can be generated
CO2 – Gain knowledge on biomass pyrolysis process and its applications
CO3 – Develop knowledge on various types of biomass gasifiers and their operations
CO4 – Gain knowledge on biomass combustors and its applications on generating energy
CO5 – Understand the principles of bio-energy systems and their features

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓		✓									✓
CO2	✓		✓									✓
CO3	✓	✓	✓		✓							✓
CO4	✓	✓	✓		✓		✓					✓
CO5	✓	✓	✓		✓							✓

REFERENCES:

1. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
2. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.

AUDIT COURSES (AC)

AX5091 ENGLISHFOR RESEARCHPAPERWRITING L T P C
2 0 0 0

OBJECTIVES

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

UNITI INTRODUCTION TO RESEARCH PAPER WRITING 6

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT II PRESENTATION SKILLS 6

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction

UNIT III TITLE WRITING SKILLS 6

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

UNIT IV RESULT WRITING SKILLS 6

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT V VERIFICATION SKILLS 6

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first-time submission

TOTAL: 30 PERIODS

OUTCOMES

CO1 –Understand that how to improve your writing skills and level of readability
CO2 –Learn about what to write in each section
CO3 –Understand the skills needed when writing a Title
CO4 – Understand the skills needed when writing the Conclusion
CO5 – Ensure the good quality of paper at very first-time submission

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3										✓		✓
CO4										✓		✓
CO5										✓		✓

REFERENCES

1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006
3. Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006
4. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book 1998.

AX5092 **DISASTER MANAGEMENT** **L T P C**
2 0 0 0

OBJECTIVES

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION 6

Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS 6

Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

UNIT III DISASTER PRONE AREAS IN INDIA 6

Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT 6

Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V RISK ASSESSMENT 6

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival

TOTAL : 30 PERIODS

OUTCOMES

CO1: Ability to summarize basics of disaster
CO2: Ability to explain critical understanding of key concepts in disaster risk reduction and humanitarian response.
CO3: Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
CO4: Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
CO5: Ability to develop the strengths and weaknesses of disaster management approaches

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES

1. Goel S. L., Disaster Administration And Management Text And Case Studies", Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. Nishitha Rai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company,2007.
3. Sahni, Pardeep Et.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi,2001.

AX5093 SANSKRIT FOR TECHNICAL KNOWLEDGE L T P C

2 0 0 0

OBJECTIVES

- Illustrate the basic sanskrit language.
- Recognize sanskrit, the scientific language in the world.
- Appraise learning of sanskrit to improve brain functioning.
- Relate sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power.
- Extract huge knowledge from ancient literature.

UNIT I ALPHABETS 6

Alphabets in Sanskrit

UNIT II TENSES AND SENTENCES 6

Past/Present/Future Tense - Simple Sentences

UNIT III ORDER AND ROOTS 6

Order - Introduction of roots

UNIT IV SANSKRIT LITERATURE 6

Technical information about Sanskrit Literature

UNIT V TECHNICAL CONCEPTS OF ENGINEERING 6

Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

TOTAL: 30 PERIODS

OUTCOMES

- CO1 - Understanding basic Sanskrit language.
- CO2 - Write sentences.
- CO3 - Know the order and roots of Sanskrit.
- CO4 - Know about technical information about Sanskrit literature.
- CO5 - Understand the technical concepts of Engineering.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3												✓
CO4												✓
CO5												✓

REFERENCES

1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi, 2017.

AX5094 **VALUE EDUCATION** **L T P C**
2 0 0 0

OBJECTIVES

Students will be able to

- Understand value of education and self-development
- Imbibe good values in students
- Let the should know about the importance of character

UNIT I

Values and self-development–Social values and individual attitudes. Workethics,Indianvisionofhumanism.Moralandnon-moralvaluation.Standards and principles. Value judgements

UNIT II

Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love fornature, Discipline

UNIT III

Personality and Behavior Development-Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour. Universal brother hood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature

UNIT IV

Character and Competence–Holy books vs Blind faith. Self-management and Good health. Science of reincarnation. Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Knowledge of self-development.
- Learn the importance of Human values.
- Developing the over all personality.

Suggested reading

1. Chakroborty, S.K.“Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi

AX5095 **CONSTITUTION OF INDIA** **L T P C**
2 0 0 0

OBJECTIVES

Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional
- Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION:

History, Drafting Committee, (Composition &Working)

UNIT II PHILOSOPHYOFTHE INDIANCONSTITUTION:

Preamble, Salient Features

UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES:

Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT IV ORGANS OF GOVERNANCE:

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT V LOCAL ADMINISTRATION:

District's Administration head: Role and Importance, • Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy(Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT VI ELECTION COMMISSION:

Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- DiscussthegrowthofthedemandforcivilrightsinIndiaforthebulkofIndiansbeforethe arrival of Gandhi in Indian politics.
- Discusstheintellectualoriginsoftheframeworkofargumentthatinformedtheconceptualization
- of social reform sliding to revolution in India.
- DiscussthecircumstancessurroundingthefoundationoftheCongressSocialistParty[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- DiscussthepassageoftheHinduCodeBillof1956.

Suggested reading

1. TheConstitutionofIndia,1950(BareAct), Government Publication.
2. Dr. S. N. Busi, Dr. B. R.AmbedkarframingofIndianConstitution,1st Edition,2015.
3. M.P. Jain,IndianConstitutionLaw,7th Edn.,Lexis Nexis,2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis,2015.

Suggested reading

1. Ackers, HardmanF(2001)ClassroominteractioninKenyanprimaryschools,Compare,31(2): 245-261.
2. AgrawalM (2004)Curricular reform in schools: The importance of evaluation, JournalofCurriculumStudies,36(3):361-379.
3. AkyeampongK(2003)TeachertraininginGhana-doesitcount?Multi-siteteachereducationresearchproject(MUSTER) country report 1.London:DFID.
4. Akyeampong K,LussierK, PryorJ, WestbrookJ (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33(3): 272–282.
5. Alexander RJ(2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. ChavanM (2003) Read India: Amass scale, rapid, 'learningtoread 'campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf

AX5097 STRESS MANAGEMENT BY YOGA L T P C
2 0 0 0

OBJECTIVES

- To achieve overall health of body and mind
- To overcome stress

UNIT I

Definitions of Eight parts of yoga.(Ashtanga)

UNIT II

Yam and Niyam - Do's and Don't'sin life - i) Ahinsa, satya, astheya, bramhacharya and aparigraha, ii) Ahinsa, satya, astheya, bramhacharya and aparigraha.

UNIT III

Asan and Pranayam - Various yog poses and their benefits for mind & body - Regularization of breathing techniques and its effects-Types of pranayam

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- Develop healthy mind in a healthy body thus improving social health also
- Improve efficiency

SUGGESTEDREADING

1. 'YogicAsanasforGroupTarining-Part-I":JanardanSwamiYogabhyasiMandal, Nagpur
2. "Rajayogaorconquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department),Kolkata

AX5098	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS	L T P C 2 0 0 0

OBJECTIVES

- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To a waken wisdom in students

UNIT I

Neetishatakam-holistic development of personality - Verses- 19,20,21,22 (wisdom) - Verses- 29,31,32 (pride & heroism) – Verses- 26,28,63,65 (virtue) - Verses- 52,53,59 (dont's) - Verses- 71,73,75,78 (do's)

UNIT II

Approach to day to day work and duties - Shrimad BhagwadGeeta: Chapter 2-Verses 41, 47,48 - Chapter 3-Verses 13, 21, 27, 35 Chapter 6-Verses 5,13,17,23, 35 - Chapter 18-Verses 45, 46, 48.

UNIT III

Statements of basic knowledge - Shrimad BhagwadGeeta: Chapter2-Verses 56, 62, 68 Chapter 12 - Verses 13, 14, 15, 16,17, 18 -Personality of role model - shrimadbhagwadgeeta - Chapter2-Verses 17, Chapter 3-Verses 36,37,42 - Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Study of Shrimad- Bhagwad- Geeta will help the student in developing his personality and achieve the highest goal in life
- The person who has studied Geeta will lead the nation and man kind to peace and prosperity
- Study of Neetishatakam will help in developing versatile personality of students.

Suggested reading

1. Gopinath, Rashtriya Sanskrit Sansthanam P, Bhartrihari's Three Satakam, Niti-sringar-vairagya, New Delhi,2010
2. Swami Swarupananda , Srimad Bhagavad Gita, Advaita Ashram, Publication Department, Kolkata, 2016.