ANNA UNIVERSITY:: CHENNAI 600 025
AFFILIATED INSTITUTIONS
M. TECH ENVIRONMENTAL SCIENCE AND TECHNOLOGY
REGULATIONS – 2017
CHOICE BASED CREDIT SYSTEM

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

The students of M.Tech Environmental Science and Technology will

1. Be employed as environmental engineers in industry, government, and private sectors and will be working toward the development of sustainable technologies for various industries.
2. Pursue higher studies, become a consultant and may start up own business.
3. Exhibit professional, ethical codes of conduct, perform service to the society and to the engineering profession through membership and participation in professional societies.

Programme Outcomes (POs)

On successful completion of this programme, the graduates will have the

1. Capacity to apply knowledge of mathematics, environmental science, and engineering
2. Ability to conduct experiments, analyze and interpret data.
3. Knowledge to design sustainable processes to meet the global challenge.
4. Capacity to formulate and solve complex problems associated with environmental engineering.
5. Ability to identify the impact of engineering solutions in a global, economic, and societal context.
6. Interest to acquire knowledge on modern analytical techniques and computational skills necessary for environmental engineers.
7. The competency in utilizing the available resources effectively and optimally.
8. Basic ability to be a member in the team consisting of people from different backgrounds.
9. Knowledge on the importance of professional and ethical responsibilities in an organization.
10. Ability to communicate their thoughts and ideas effectively.
11. Inclination towards acquiring knowledge on the latest developments in the field of environmental engineering.

Programme Educational Objectives	Programme Outcomes										
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
I	✓	✓	✓	✓	✓	✓	✓	✓			
II				✓	✓		✓	✓	✓	✓	✓
III								✓	✓	✓	✓

			PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11
YEAR I	SEM I	Advanced Numerical Methods	✓	✓	✓		✓	✓					
		Biological Wastewater Treatment	✓	✓	✓			✓	✓				
		Environmental Chemistry	✓	✓	✓	✓							
		Unit Operations and Unit Processes in Environmental Technology	✓		✓				✓				
		Professional Elective I											
		Professional Elective II											
		Environmental Engineering Lab		✓		✓		✓					
	SEM II	Air and Noise Pollution Control	✓		✓			✓	✓				
		Environmental Impact Assessment			✓		✓			✓	✓		
		Separation Processes in Environmental Applications	✓		✓			✓	✓				
		Solid and Hazardous Waste Management	✓		✓						✓		✓
		Professional Elective III											
		Professional Elective IV											
		Seminar						✓		✓		✓	✓
YEAR II	SEM III	Modeling of Environmental Systems				✓		✓					✓
		Professional Elective V											

		Professional Elective VI											
		Internship				✓		✓				✓	✓
		Project Work (Phase I)				✓		✓				✓	✓
	SEM IV	Project Work (Phase II)				✓		✓				✓	✓

ANNA UNIVERSITY:: CHENNAI 600 025
AFFILIATED INSTITUTIONS
M. TECH ENVIRONMENTAL SCIENCE AND TECHNOLOGY
REGULATIONS – 2017
CHOICE BASED CREDIT SYSTEM
I TO IV SEMESTERS CURRICULUM AND SYLLABUS

SEMESTER – I

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIOD	L	T	P	C
THEORY								
1.	MA5153	Advanced Numerical Methods	FC	5	3	2	0	4
2.	ES5101	Biological Wastewater Treatment	PC	3	3	0	0	3
3.	ES5102	Environmental Chemistry	FC	3	3	0	0	3
4.	ES5103	Unit Operations and Unit Processes in Environmental Technology	PC	3	3	0	0	3
5.		Professional Elective I	PE	3	3	0	0	3
6.		Professional Elective II	PE	3	3	0	0	3
LABORATORY								
7.	ES5111	Environmental Engineering Laboratory	PC	4	0	0	4	2
			TOTAL	**24**	**18**	**2**	**4**	**21**

SEMESTER – II

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIOD	L	T	P	C
THEORY								
1.	ES5201	Air and Noise Pollution Control Engineering	PC	3	3	0	0	3
2.	ES5202	Environmental Impact Assessment	PC	3	3	0	0	3
3.	ES5203	Separation Processes in Environmental Applications	PC	5	3	2	0	4
4.	ES5204	Solid and Hazardous Waste Management	PC	3	3	0	0	3
5.		Professional Elective III	PE	3	3	0	0	3
6.		Professional Elective IV	PE	3	3	0	0	3
LABORATORY								
7.	ES5211	Seminar	EEC	4	0	0	4	2
			TOTAL	**24**	**18**	**2**	**4**	**21**

SEMESTER – III

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIOD	L	T	P	C
THEORY								
1.	ES5301	Modeling of Environmental Systems	PC	5	3	2	0	4
2.		Professional Elective V	PE	3	3	0	0	3
3.		Professional Elective VI	PE	3	3	0	0	3
LABORATORY								
1.	ES5311	Internship	EEC	2	0	0	2	1
2.	ES5312	Project Work Phase I	EEC	12	0	0	12	6
			TOTAL	**25**	**9**	**2**	**14**	**17**

SEMESTER – IV

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIOD	L	T	P	C
LABORATORY								
1.	ES5411	Project Work Phase II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL CREDITS : 71

List of Professional Electives (PE)

SEMESTER – I, PROFESSIONAL ELECTIVE - I

S. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1.	CX5091	Safety and Hazard Control	PE	3	3	0	0	3
2.	ES5001	Environmental Policies and Legislation	PE	3	3	0	0	3
3.	ES5002	Environmental Sustainability	PE	3	3	0	0	3
4.	ES5003	Ecology and Environment	PE	3	3	0	0	3

SEMESTER – I, PROFESSIONAL ELECTIVE - II

S. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1.	EV5091	Marine Pollution and Control	PE	3	3	0	0	3
2.	ES5071	Environmental Risk Assessment	PE	3	3	0	0	3
3.	ES5004	Waste Water Engineering	PE	3	3	0	0	3
4.	CX5076	Industrial Instrumentation	PE	3	3	0	0	3
5.	ES5091	Industrial Pollution Prevention	PE	3	3	0	0	3

SEMESTER – II, PROFESSIONAL ELECTIVE - III

S. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	CX5096	Membrane Technologies for Water and Wastewater Treatment	PE	3	3	0	0	3
2.	ES5005	Atmospheric Science	PE	3	3	0	0	3
3.	ES5006	Enviromental Reaction Engineeing	PE	3	3	0	0	3
4.	ES5007	Advanced Oxidation Processes and Technology	PE	3	3	0	0	3
5.	ES5008	Pollution Abatement	PE	3	3	0	0	3

SEMESTER – II, PROFESSIONAL ELECTIVE - IV

S. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	CX5079	Environmental Nanotechnology	PE	3	3	0	0	3
2.	ES5009	Biotechnology in Environmental Applications	PE	3	3	0	0	3
3.	ES5010	Soil Pollution Engineering	PE	3	3	0	0	3
4.	CX5095	Environment, Health and Safety in Industries	PE	3	3	0	0	3
5.	ES5011	Remote Sensing and GIS Applications in Enviromental Management	PE	3	3	0	0	3

SEMESTER – III, PROFESSIONAL ELECTIVE - V

S. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	CX5092	Energy Management	PE	3	3	0	0	3
2.	ES5012	Climate Change and Adaptation	PE	3	3	0	0	3
3.	ES5013	Waste Management and Energy Recovery	PE	3	3	0	0	3
4.	ES5092	Design of Experiments	PE	3	3	0	0	3
5.	ES5014	Bio-Energy Conservation Techniques	PE	3	3	0	0	3

SEMESTER – III, PROFESSIONAL ELECTIVE - VI

S. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	CX5080	Operations Research	PE	3	3	0	0	3
2.	CX5081	Intellectual Property Rights	PE	3	3	0	0	3
3.	CX5094	Hydrogen and Fuel Cells	PE	3	3	0	0	3
4.	PP5391	Corrosion Engineering	PE	3	3	0	0	3
5.	CX5083	Green chemistry and Engineering	PE	3	3	0	0	3

Foundation Courses (FC)

S.No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MA5153	Advanced Numerical Methods	FC	5	3	2	0	4
2.	ES5102	Environmental Chemistry	FC	3	3	0	0	3

Professional Core (PC)

S. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	ES5101	Biological Wastewater Treatment	PC	3	3	0	0	3
2.	ES5103	Unit Operations and Unit Processes in Environmental Technology	PC	3	3	0	0	3
3.	ES5201	Air and Noise Pollution Control Engineering	PC	3	3	0	0	3
4.	ES5202	Environmental Impact Assessment	PC	3	3	0	0	3
5.	ES5203	Separation Processes in Environmental Applications	PC	5	3	2	0	4
6.	ES5204	Solid and Hazardous Waste Management	PC	3	3	0	0	3
7.	ES5301	Modeling of Environmental Systems	PC	5	3	2	0	4
8.	ES5111	Environmental Engineering Laboratory	PC	4	0	0	4	2

Employability Enhancement Courses (EEC)

S.No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	ES5211	Seminar	EEC	4	0	0	4	2
2.	ES5311	Internship	EEC	2	0	0	2	1
3.	ES5312	Project Work Phase I	EEC	12	0	0	12	6
4.	ES5411	Project Work Phase II	EEC	24	0	0	24	12

MA5153	ADVANCED NUMERICAL METHODS (Common to Environmental Science and Technology, Chemical Engineering and PRPC)	L	T	P	C
		3	2	0	4

OBJECTIVES :

- The course will develop numerical methods aided by technology to solve algebraic, transcendental and differential equations and to apply finite element methods for solving the boundary value problems in differential equations. The course will further develop problem solving skills and understanding of the application of various methods in solving engineering problems. This will also serve as a precursor for future research.

UNIT I ALGEBRAIC EQUATIONS 12+3

Systems of linear equations : Gauss elimination method – Pivoting techniques – Thomas algorithm for tri diagonal system – Jacobi, Gauss Seidel, SOR iteration methods – Conditions for convergence - Systems of nonlinear equations : Fixed point iterations, Newton's method, Eigenvalue problems : Power method and Given's method.

UNIT II ORDINARY DIFFERENTIAL EQUATIONS 12+3

Runge - Kutta methods for system of IVPs – Numerical stability of Runge - Kutta method – Adams - Bashforth multistep method, Shooting method, BVP : Finite difference method, Collocation method and orthogonal collocation method.

UNIT III FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATIONS 12+3

Parabolic equations : Explicit and implicit finite difference methods – Weighted average approximation - Dirichlet's and Neumann conditions – Two dimensional parabolic equations – ADI method : First order hyperbolic equations – Method of numerical integration along characteristics – Wave equation : Explicit scheme – Stability.

UNIT IV FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS 12+3

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

UNIT V FINITE ELEMENT METHOD 12+3

Basics of finite element method : Weak formulation, Weighted residual method – Shape functions for linear and triangular element – Finite element method for two point boundary value problems, Laplace and Poisson equations.

TOTAL : 60+15=75 PERIODS

OUTCOMES :

After completing this course, students should demonstrate competency in the following skills:

- Solve an algebraic or transcendental equation, linear system of equations and differential equations using an appropriate numerical method.
- Solving the initial boundary value problems and boundary value problems using finite difference and finite element methods.
- Selection of appropriate numerical methods to solve various types of problems in engineering and science in consideration with the minimum number of mathematical operations involved, accuracy requirements and available computational resources.

REFERENCES :

1. Burden, R.L., and Faires, J.D., "Numerical Analysis – Theory and Applications", 9th Edition, Cengage Learning, New Delhi, 2016.
2. Gupta S.K., "Numerical Methods for Engineers", New Age Publishers, 1995.
3. Jain M. K., Iyengar S. R., Kanchi M. B., Jain, "Computational Methods for Partial Differential Equations", New Age Publishers ,1993.
4. Sastry, S.S., "Introductory Methods of Numerical Analysis", 5th Edition, PHI Learning, 2015.
5. Saumyen Guha and Rajesh Srivastava, "Numerical methods for Engineering and Science", Oxford Higher Education, New Delhi, 2010.
6. Smith, G. D., "Numerical Solutions of Partial Differential Equations: Finite Difference Methods", Clarendon Press, 1985.

ES5101 BIOLOGICAL WASTE WATER TREATMENT L T P C
3 0 0 3

OBJECTIVE

- 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 **9**

Classification of Biochemical Operations, Fundamentals of Biochemical Operations, Stoichiometry and Kinetics of Biochemical Operations.

UNIT II **9**

Theory, Modeling of Ideal Suspended Growth Reactors, Modeling Suspended Growth Systems, Aerobic Growth of Heterotrophs in a Single Continuous Stirred Tank, Reactor Receiving Soluble Substrate, Multiple Microbial Activities in a Single Continuous Stirred Tank Reactor, Multiple Microbial Activities in Complex Systems, Techniques for Evaluating Kinetic and Stoichiometric Parameters

UNIT III **9**

Applications: Suspended Growth Reactors, Design And Evaluation of Suspended Growth Processes, Activated Sludge, Biological Nutrient Removal, Aerobic-digestion, Anaerobic Processes, Lagoons

UNIT IV **9**

Theory: Modeling of Ideal Attached Growth Reactors, Bio-film Modeling Aerobic Growth of

Biomass in PackedTowers, Aerobic Growth of Heterotrophs in Rotating Disc Reactors, Fluidized Bed Biological Reactors,

UNIT V **9**

Applications: Attached Growth Reactors, Trickling Filter, Rotating Biological Contactor, Submerged Attached Growth Bioreactors, Future Challenges, Fate and Effects of Xenobiotic Organic Chemicals, Industrial wastewater treatment.

TOTAL : 45 PERIODS

OUTCOME:

- This course will make the students to design biological treatment uints
- To undertake projects on biological wastewater treatment

REFERENCES

1. Grady, C.P.L, Daigger, G and Lim, H.C, Biological Wastewater Treatment, 2nd Ed, Marcel Dekker, 1999
2. Mizrahi A, Biological Waste Treatment, John Wiley Sons Inc 1989.
3. Patwardhan A.D. Industrial Wastewater Treatment, Prentice Hall of India Ltd, New Delhi, 2008.

ES5102 **ENVIRONMENTAL CHEMISTRY** **L T P C**
3 0 0 3

OBJECTIVE

- To impart knowledge on chemistry aspects of environment.
- Analysis of chemical methods in environmental engineering.

UNIT I **9**

Significance of Environmental Chemistry for Wastewater Engineering- Basic concepts of cell biology, metabolism, energetic of bio chemical reactions, enzymes and their importance in aerobic and anaerobic microbiological reactions, specific importance of cofactors, transport of materials in the organisms

UNIT II **9**

Chemical equilibrium in gaseous and solutions, free energy change, entropy change of reactions in solutions,

UNIT III **9**

Basic concepts of electro chemistry, Debye-Huckel Theory, solubility of strong electrolytes, acids and bases, buffers, pH, interpretation of pH data. Colloids, osmosis, viscosity of colloidal suspension, Brownian movement and diffusion sedimentation, surface forces, electrical properties of surfaces

UNIT IV **9**

Colloids, osmosis, viscosity of colloidal suspension, Brownian movement and diffusion sedimentation, surface forces, electrical properties of surfaces

UNIT V **9**

Sampling and characterization of water and wastewater by gravimetric, volumetric and colorimetric methods - Sampling and analysis of ambient air for SPM, SO2, and Oxides of nitrogen - Good laboratory practice - Analytical quality control.

TOTAL : 45 PERIODS

OUTCOME:

- Be familiar with basic concepts of chemistry to understand the fundamental underlying mechanism.
- Be familiar with sampling of wastes.

REFERENCES

1. Rajeshwar, K. and Ibanez, J. G., Environmental Electrochemistry Academic Press, 1997.
2. Sawyer C L McCarty P L and Parkin G E, Chemistry for Environmental Engineering. McGraw Hill, 1995
3. VanLoon G W and S.J. Duffy, Environmental Chemistry, Oxford university press, 2005

ES5103 UNIT OPERATIONS AND UNIT PROCESSES IN ENVIRONMENTAL TECHNOLOGY **L T P C**

3 0 0 3

OBJECTIVE:

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

UNIT I **9**

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

UNIT II **9**

Sedimentation - Type of settling - Removal ratio – Clarifier-thickener- Column flotation- air flotation. **Design approach:** Clarifier, Tube settler.

UNIT III **9**

Filtration – classification of filters-Head loss through filters– Darcy equation. **Design approach:** Activated carbonfillers, Filter press, Pressure sand filter.

UNIT IV **9**

Chemical precipitation - phosphate removal - Adsorption - Activated carbon - Isotherms – Disinfection – Factors Influencing - Breakpoint chlorination - Dechlorination. **Design approach:** UV disinfection, water chlorination

UNIT V **9**

Kinetics of Biological growth - Suspended and attached growth processes - Aerobic and Anaerobic - Determination of kinetic coefficients. **Design approach:** Aeration equipments,

anerobic digester, UASBR, Secured land fill

TOTAL : 45 PERIODS

OUTCOME:

- To make the students to understand advanced courses better.
- To design the treatment plants with fundamental understanding.

REFERENCES

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

ES5111 ENVIRONMENTAL ENGINEERING LABORATORY L T P C
0 0 4 2

OBJECTIVE:

- To impart practical knowledge about various environmental related processes.
- To understand the practical implications associated with the estimation diffeternt parameters related to environmental engineering.

1. Studies on isolation of microorganism for wastewater treatment.
2. Sampling and analysis of air pollutants ambient and stacks (SPM, RPM, SO_2, NO_X 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 pollutants and determination of sludge volume index.
8. Studies on treatment of effluents using electrochemical reactor.
9. Batch adsorption studies using activated carbon and dye.
10. Treatment of waste water by Advanced Oxidation Technology.

TOTAL : 60 PERIODS

OUTCOME:

- The students gain better understanding about the processes.
- The students will have the capacity to develop experiments related to their field of research.

List of Equipments required for Environmental Engineering Lab

S.No	Description of Equipment	Quantity required
1	Laminar Air Flow Chamber	1

2	LPG Gas Cylinder	1
3	Autoclave	1
4	Deep Freezer	1
5	Centrifuge	1
6	Refrigerator	1
7	Hot Air Oven	1
8	Microscope	1
9	Magnetic Stirrer	1
10	Electronic Balance	1
11	Conductivity Meter	1
12	Heating Mantle	2
13	Shaker Incubator	2
14	SPM Filter	1
15	Microfiber Filter	1
16	Infra Red Gas Analyzer	1
17	Furnace	2
18	COD Reflux	3
19	COD Digester	1
20	BOD Incubator	1
21	Clarifier	2
22	Jar Test Apparatus	1
23	Turbidity Meter	1
24	pH Meter	1
25	Thermometer	2
26	Bioreactor	1

27	Electrochemical Reactor	1
28	Photo Reactor	1
29	UV Chamber /Reactor	1
30	Photo Catalytic Reactor	1
31	Sonochemical Reactor	1
32	High Performance Liquid Chromatography	1
33	UV-Vis Spectrophotometer	1
34	Atomic Absorption Spectroscopy	1
35	Fourier transform infrared spectroscopy	1

ES5201 AIR AND NOISE POLLUTION CONTROL ENGINEERING L T P C
3 0 0 3

OBJECTIVE:

- To illustrate the major problems in air pollution and control.
- To describe the air pollution control measures and devices.
- To impart basic knowledge on noise pollution control.

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 Aluminum Manufacturing; Air Pollution from Copper Smelting;

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

OUTCOME:

- Be familiar with air pollution remedial measures and their importance.
- The students will undertake projects related to air pollution control.

REFERENCES

1. Anjaneyulu. Y, 'Air Pollution and Control Technologies', Allied Publishers (P) Ltd., India, 2002.
2. Arthur C.Stern, ' Air Pollution (Vol.I – Vol.VIII)', Academic Press, 2006.
3. David H.F. Liu, Bela G. Liptak 'Air Pollution', Lweis Publishers, 2000.
4. Heck, R.M and Farrauto, R.J, Catalytic Air Pollution Control: Commercial Technology, 2nd Edition John Wiley Sons, 2012
5. Jeffrey Pierce J, Environmental pollution and control, Butterworth-Heinemann; 4th edn, 1997.
6. Lawrence K. Wang, Norman C. Parelra, Yung Tse Hung, Air Pollution Control Engineering, Tokyo, 2004.
7. Noel de Nevers, Air Pollution Control Engineering, McGraw Hill, New York, 2011.
8. Wayne T.Davis, 'Air Pollution Engineering Manual', John Wiley & Sons,Inc.,2000.

ES5202 ENVIRONMENTAL IMPACT ASSESSMENT **L T P C**

3 0 0 3

OBJECTIVE:

- To learn about the importance of Environmental Impact Assessment.
- To 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 in Food, Fertilizer and Petrochemical industry.

TOTAL : 45 PERIODS

OUTCOME:

- The students will be in a position to make decision based on the environmental consequences of proposed actions.
- The students will promote environmentally sound and sustainable development by identifying appropriate measures.

REFERENCES

1. Canter, L.W., Environmental Impact Assessment, McGraw Hill, New York, 1996.
2. Lawrence, D.P., Environmental Impact Assessment – Practical solutions to recurrent problems, Wiley-Interscience, New Jersey, 2003.
3. Petts, J., Handbook of Environmental Impact Assessment Vol. I and II, Blackwell Science, London, 2009.
4. The World Bank Group, Environmental Assessment Sourcebook Vol. I, II and III, The World Bank, Washington, 1991.

ES5203 SEPARATION PROCESSES IN ENVIRONMENTAL APPLICATIONS **L T P C 3 2 0 4**

OBJECTIVE:

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

UNIT I **9+6**

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

UNIT II **9+6**

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+6**

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

UNIT IV **9+6**

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

UNIT V **9+6**

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

TOTAL : 75 PERIODS

OUTCOME:

- The students will understand the importance of separation processes in environmental applications.
- The students will be in a position to select the best separation process for a given problem.

REFERENCES

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

ES5204 SOLID AND HAZARDOUS WASTE MANAGEMENT **L T P C**

3 0 0 3

OBJECTIVE:

- To provide comprehensive overview of solid and hazardous waste management.
- To provide knowledge on solide waste management design aspects.

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 resposibilities.

UNIT II **9**

Collection of Solid Waste: type of waste collection systems, analysis of collection system - alternative techniques for collection system. Separation and Processing and Transformation of Solid Waste: unit operations used for separation and processing, Materials Recovery facilities, Waste transformation through combustion and anerobic 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.

UNIT IV **9**

Hazardous waste treatment technologies - Design and operation of facilities for physical, chemical and thermal treatment of hazardous waste - 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

TOTAL : 45 PERIODS

OUTCOME:

- Be familiar with solid waste remedial measures and their importance.
- The students will undertake projects related to solid waste managemet.
- Be familiar with legislations pertaining to solid waste management.

REFERENCES

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

ES5211 **SEMINAR** **L T P C**

0 0 4 2

OBJECTIVE:

- To provide exposure to the recent developments.
- To improve the students presentation skills.

OUTCOME:

- The sudents will get better emplyability and communication skills.

Students are expected to present two seminars along with report on any recent topic in Environmental Science and Technology

ES5301 MODELING OF ENVIRONMENTAL SYSTEMS L T P C
3 2 0 4

OBJECTIVE:

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

UNIT I 9+6

Basic concepts in ecology and ecological modeling, Population Dynamics: Birth and death processes. Single species growth, Prey-predator models: Lotka-Volterra, Rosenzweig-MacArther, Kolmogorov models. Multi-species modeling, Primary production, primary and secondary consumers, Structural analysis and stability of complex ecosystems.

UNIT II 9+6

Continuous-Flow Reactor Modeling: CSTR, Plug-Flow, Dispersion. A case study of a tubular reactor with axial dispersion, Parameter Calibration: Search algorithms for nonlinear dynamical models, Variance of estimated parameters. Application to Monod and Haldane kinetics.

UNIT III 9+6

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 9+6

Fundamentals of microbial dynamics and energetics. Pollutant/Microorganisms interactions, Requirements for carbon and nutrient removal. Activated sludge: Process schemes: completely mixed, plug-flow, SBR, nutrient removal. Anaerobic digestion: process dynamics, Operational control of wastewater treatment processes.

UNIT V 9+6

Fuzzy System Modeling Introduction to fuzzy sets and systems, fuzzification, implication, connectives, defuzzification, rule-based fuzzy models with different approaches (Mamdani and Sugeno). Cluster analysis for the classification of ecological data,. Integration between fuzzy clustering and fuzzy models.

TOTAL : 75 PERIODS

OUTCOME:

- The students will be in a position to develop and construct models

- Be familiar with fuzzy logic based models.

REFERENCES

1. Arthur C.Stern., Air Pollution (Third Ed.) Volume I – Air Pollutants, their transformation and Transport, (Ed.), Academic Press, 2006.
2. Chapra, S.C. Surface Water-Quality Modeling, McGraw-Hill, 2008.
3. Deaton, M.L and Winebrake, J.J., Dynamic Modeling of Environmental Systems, Verlag, 2000.
4. Orhon, D and Artan, N., Modeling of Activated Sludge Systems, Technomic Publ. Co., 1994.
5. Schnoor, J.L., Environmental Modeling Fate and Transport of Pollutants in Water, Air and Soil, John Wiley & Sons Inc., New York, 1996.

ES5312 PROJECT WORK PHASE I L T P C
0 0 12 6

OBJECTIVE:

- To apply the principles learned from variorius courses to solve real time problem.

Students have to do a research-based project in the department or in an industry and submit a report at the end of Phase I

ES5411 PROJECT WORK PHASE II L T P C
0 0 24 12

OBJECTIVE:

- To apply the principles learned from variorius courses to solve real time problem.

OUTCOME:

The students will get confidence to solve challenging problems.

Phase II of Project Work is a continuation of Phase I of Project. Students submit a report at the end of Phase II.

CX5091 SAFETY AND HAZARD CONTROL L T P C
3 0 0 3

OBJECTIVES

- Become a skilled person in HAZOP and hazard analysis and able to find out the root cause of an accident. Gain knowledge in devising safety policy and procedures to be adopted to implement total safety in a plant.

UNIT I **9**

Conventional and modern concepts of safety, Basic Principles and concepts in hazard identification, Chemical hazards, Process and operation hazard, Hazards from utilities like air, water, steam etc., Occupational health hazards, Hazard and operability Studies, Safety Audits.

UNIT II **9**

Past Accident Analysis, Consequence Analysis of fire, gas/vapour, Dispersions and explosion, Vulnerability models, Fault and Event Tree Analysis.

UNIT III **9**

Safety in plant design and layout. Risk Assessment.

UNIT IV **9**

Safety measures in handling and storage of chemicals, Process plant, personnel Protection, First Aid.

UNIT V **9**

Disaster mitigation, Emergency Preparedness plans.

TOTAL: 45 PERIODS

OUTCOME:

- Students understand that behind each fatality or serious injury there are thousands of at - risk behaviours and unidentified hazards that contributed to the incident
- State the definition of a hazard and explain how to identify hazards in the industries/workplace.
- Determine methods for controlling hazards in the workplace.
- Complete a Job Hazard Analysis for a typical worker task.

REFERENCES

1. Coulson J.M and Richardson J.F., Chemical Engineering, Vol. 1 (Chaper 4) Asian Book House Pvt. Ltd., New Delhi. 1998.
2. Frank P.Less, Loss Prevention in Process Industries, Vol. I and Vol II Butterworth, London, 1980.
3. Guidelines for Chemical Process Quantitative Risk Analysis, Published by Centre for Chemical Process Safety of the AICh.E., New York, USA. 1989.
4. Major Hazard Control, Manual by International Labour Organization, Geneva, 1990.
5. Marshal, V.C Major Chemical Hazards, Ellis Harwood Ltd. Chichester, U.K. 1987.
6. R.K.Sinnott, Coulson & Richardson's Chemical Engineering, Vol.6 Butlerworth – Heinmann. Oxford, 1996.
7. Raghavan, K.V and A.A Khan, Methodologies in Hazard Identification and Risk Assessment, Manual by CLRI., Dec, 1990.
8. Safety in Chemical and Petrochemical Industries, Report of the Inter Ministry Group, Dept. of Chemicals and Petrochemicals, Govt.of India, ICMA Publications. 1986.
9. Well, G.S Safety Process Plants Design, George Godwin Ltd., London, John Wilelys and Sons, New York, 1980.

ES5001 ENVIRONMENTAL POLICIES AND LEGISLATION L T P C

3 0 0 3

OBJECTIVE

- To familiarize the students with policy and the policy formation process in each of the areas indicated below
- To provide students with substantive expertise necessary to analyze environmental policy proposals and the political considerations that produced those proposals

UNIT I INTRODUCTION 9

Indian Constitution and Environmental Protection – National Environmental policies – 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

OUTCOME

- On completion of the course, the students are expected to be familiar in environmental policies and legislation pertaining to industries.

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. GregerI.Megregor, “Environmental law and enforcement”, Lewis Publishers, London. 1994.
3. Shyam Divan and Armin Roseneranz “Environmental law and policy in India “Oxford University Press, New Delhi, 2001.

ES5002 ENVIRONMENTAL SUSTAINABILITY L T P C

3 0 0 3

OBJECTIVE

- To understand the concept of sustainable environment
- To understand the comprehensive systemic analysis across both physical and behavioral dimensions involving society, the environment, and the economy.

UNIT I **9**

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

UNIT II **9**

Sustainable Development: Defining the Concept, The Population Problem, Natural Resource Economics: An Overview, Energy, Water, Agriculture

UNIT III **9**

Biodiversity, Forest Habitat, Commercially Valuable Species, Stationary-Source Local Air Pollution, Acid Rain and Atmospheric Modification, Transportation

UNIT IV **9**

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

UNIT V **9**

Development, Poverty, and the Environment, Visions of the Future, Environmental economics and policy by Tom Tietenberg, Environmental Economics.

TOTAL : 45 PERIODS

OUTCOMES:

- Students will analyze the role of environmental sustainability in the promotion of comprehensive justice and equity.
- They will apply critical thinking skills to provide sustainable solutions and build resilient communities.
- They will utilize the appropriate methodological tools to analyze and address specific research questions.

REFERENCES

1. Andrew Hoffman, Competitive Environmental Strategy -A Guide for the Changing Business Landscape, Island Press.

2. Stephen Doven, Environment and Sustainability Policy : Creation, Implementation, Evaluation, The Federation Press, 2005.

ES5003 ECOLOGY AND ENVIRONMENT L T P C
3 0 0 3

OBJECTIVE

- To understand the complex interactions of humans and ecological systems in the natural world.
- To learn the basic statistical analysis or systems modeling methodology in environmental analysis.

UNIT I **10**

Aim - scope and applications of Ecology, Ecological Engineering and Ecotechnology and their relevance to human civilization - Development and evolution of ecosystems -Principles and concepts pertaining to communities in ecosystem - Energy flow and material cycling in ecosystems - Productivity in ecosystems.

UNIT II **10**

Classification of ecotechnology - Principles and components of Systems and Modeling - Structural and functional interactions in environmental systems - Human modifications of environmental 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 - Agro ecosystems - Determination of sustainable loading of ecosystems.

UNIT IV **10**

Principles and operation of soil infiltration systems - wetlands and ponds – source separation systems aqua cultural systems - detritus based treatment for solid wastes -Applications of ecological engineering marine systems.

UNIT V **5**

Case studies of integrated ecological engineering systems

TOTAL : 45 PERIODS

OUTCOMES:

- Students will be able to interpret, synthesize, and apply a wide range of scientific literature in the ecological and environmental sciences, particularly dealing with both climate change and global change.
- They will be able to interpret environmental, resource management, and sustainability conflicts from multiple perspectives.
- They will be able to effectively analyze and integrate the social and natural sciences to understand diverse environmental and sustainability challenges ranging from local issues to global environments.

REFERENCES

1. Ignaci Muthu S, 'Ecology and Environment' Eastern Book Corporation, 2007.
1. Krebs, Charles J. 2001. Ecology: The Experimental Analysis of Distribution and Abundance. 5th edition.
2. Mitsch, J.W. and Jorgensen, S.E., Ecological Engineering, An Introduction to Ecotechnology, John Wiley & Sons, New York, 1989.

EV5091 MARINE POLLUTION AND CONTROL L T P C
3 0 0 3

OBJECTIVES:

- To educate the Coastal and Marine Environment.
- To educate the ocean dynamics
- To find sources of marine pollution and methods for monitoring, modeling and control.

UNIT I MARINE AND COASTAL ENVIRONMENT 9

Seas and oceans, Continental area, Coastal zone, Properties of sea water, Principles of Marine Geology, coastal features – Beaches, Estuaries, Lagoons–The oceans and climate

UNIT II OCEAN HYDRODYNAMICS 9

Wave Theory, Waves in shallow waters – Refraction, Diffraction and Shoaling, Approximations for deep and shallow water conditions – Tidal Classification - General circulation of ocean waters - Ocean currents - Coastal sediment transport - Onshore offshore sediment transport - Beach formation and coastal processes - Tsunamis, storm surge, El Niño effect.

UNIT III MARINE POLLUTION SOURCES AND EFFECTS 9

Sources of Marine Pollution – Point and non-point sources, Pollution caused by Oil Exploration, Dredging, Offshore Structures, Agriculture Impacts of pollution on water quality and coastal ecosystems – Marine discharges and effluent standards.

UNIT IV MARINE POLLUTION MONITORING 9

Basic measurements - Sounding boat, lead lines, echo sounders – current meters - tide gauge - use of GPS – Measurement of coastal water characteristics – sea bed sampling – Modeling of Pollutant transport and dispersion - Oil Spill Models - Ocean Monitoring satellites – Applications of Remote Sensing and GIS in monitoring marine pollution

UNIT V COASTAL MANAGEMENT 9

Pollution Control strategies – Selection of optimal Outfall locations - National and International Treaties, Coastal Zone Regulation – Total Maximum Daily Load applications – Protocols in Marine Pollution – ICZM and Sustainable Development

TOTAL: 45 PERIODS

OUTCOMES:

- Ability to know about marine environment. And learnt the physical concepts lying behind the oceanic currents and natural processes of various activities happening over the marine environment.
- Acquired knowledge on the marine pollution and the effect of the same on the ecology.

- Should have gained knowledge on remote sensing and various other techniques for measuring and monitoring oceanic environment parameters.
- Should have acquired knowledge on control of marine pollution and sustainable development.

REFERENCES:

1. Laws, E.A., "Aquatic pollution", an introductory text. John Wiley and Sons, Inc., New York, 2000.
2. Marine pollution Dr.P. C.Sinha , Anmol Publications Pvt. Ltd, 1998.
3. Marine Pollution R.B. Clark, C. Frid and M Atttrill, Oxford Science Publications, 5th Edition, 2005.
4. Marine Pollution: New Research - Tobias N. Hofer, Nova Publishers, 2008
5. Practical Handbook of Estuarine and Marine Pollution, Michael J. Kennish, Volume 10 of CRC Marine Science, CRC Press, 1996.

ES5071 ENVIRONMENTAL RISK ASSESSMENT L T P C

3 0 0 3

OBJECTIVE

- 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**

Risk analysis introduction, quantitative risk assessment, rapid risk analysis –comprehensive risk analysis – identification, evaluation and control of risk

UNIT II **9**

Risk assessment – introduction and available methodologies, Risk assessment steps, Hazard identification, 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, EMS models – case studies – marketing terminal, gas processing complex.

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

TOTAL : 45 PERIODS

OUTCOMES:

- Students will gain the knowledge and understanding of the methods and processes employed in environmental health and risk assessment.
- They will use different tools to aid the risk assessment analysis.
- They will gain the knowledge on environmental laws and regulations to develop guidelines, procedures and processes for health and safety issues.
- They will use epidemiological data and to analyze the various methods of risk assessment.

REFERENCES

1. Crowl,D.A and Louvar,J.F., Chemical process saftery; Fundamentals with applications,prentice hall publication inc., 2002.
2. Houstan,H.B., Process safety analysis, Gulf publishing company, 1997
3. Khan,F.I and Abbasi,S.A., Risk assessment of chemical process industries; Emerging technologies, Discovery publishing house, New Delhi, 1999.

ES5004 **WASTE WATER ENGINEERING** **L T P C**

3 0 0 3

OBJECTIVES:

- To learn about the different types of wastewater treatment methods
- To understand the design of the wastewater treatment units.

UNIT I INTRODUCTION **10**

Industrial scenario - Uses of Water by industry - Sources and types of industrial wastewater – Industrial wastewater disposal and environmental impacts - Reasons for treatment of industrial wastewater – Regulatory requirements - Industrial waste survey -Industrial wastewater generation rates, characterization and variables – Population equivalent - Toxicity of industrial effluents and Bioassay tests - Preventing and minimizing
wastes at the source - Individual and Common Effluent Treatment Plants - Joint treatment of industrial wastewater.

UNIT II INDUSTRIAL WASTEWATER TREATMENT **10**

Equalisation - Neutralisation - Oil separation - Flotation - Precipitation - Heavy metal Removal – Refractory organics separation by adsorption - Aerobic and anaerobic biological treatment - Sequencing batch reactors – High Rate reactors

UNIT III ADVANCED WASTEWATER TREATMENT AND REUSE **8**

Chemical oxidation - Ozonation - Photocatalysis - Wet Air Oxidation - Evaporation – Ion Exchange – Membrane Technologies - Nutrient removal - Land Treatment.

UNIT IV RESIDUALS MANAGEMENT 5

Residuals of industrial wastewater treatment - Quantification and characteristics of Sludge - Thickening, digestion, conditioning, dewatering and disposal of sludge - Management of RO rejects.

UNIT V CASE STUDIES 12

Industrial manufacturing process description, wastewater characteristics and waste treatment flow sheet for Textiles - Tanneries - Pulp and paper - metal finishing - Petroleum Refining - Chemical industries - Sugar and Distilleries -Dairy - Iron and steel - fertilizers -Industrial clusters and Industrial Estates.

TOTAL : 45 PERIODS

OUTCOMES:

- Students will be able to provide the suitable wastewater treatment unit to particular kind of wastewater.
- They will apply the basic sciences to solve the wastewater treatment problems.
- They will design the wastewater treatment units for specific wastewater.

REFERENCES

1. Arceivala, S. J., "Wastewater Treatment for Pollution Control", Tata McGraw Hill, 1998.
2. Eckenfelder, W. W., "Industrial Water Pollution Control", Mc-Graw Hill, 1999.
3. Nelson Leonard Nemerow, Industrial waste treatment - Contemporary practice and vision for the future. Elsevier, Singapore 2007
4. "Pollution Prevention and Abatement Handbook – Towards Cleaner Production ", World Bank and UNEP, Washington, 1998.

CX5076 INDUSTRIAL INSTRUMENTATION L T P C

3 0 0 3

OBJECTIVES

- Students get the knowledge on how to measure process variables, analytical instrumentation, 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

OUTCOMES

- Students get the knowledge on how to measure process variables, analytical instrumentation, automatic process controls.

REFERENCES

1. Astrom K.J., Bjon wittenmark, Computer controlled systems, Prentice- Hall of India, New Delhi1994.
2. Cartis Johnson, Process Control Instrumentation Technology, Prentice-Hall of India, New Delhi 1993.
3. Considine D M and Considine G D “Process Instruments Controls” Handbook 3rd Edition, McGraw – Hill Book Co., NY, 1990.
4. Eckman D.P. “Industrial Instrumentation”, Wiley Eastern Ltd., 1989.
5. Ernest Doebelin, Measurement systems, McGraw – Hill Book, Co., NY, 1975.
6. Fribance, “Industrial Instrumentation Fundamentals” ,Mc Graw Hill Co. Inc. New York 1985
7. Scborg D E,.Edgar T.F and Mellichamp D.A, “Process Dynamics and Control” John Wiley 1989.

ES5091 **INDUSTRIAL POLLUTION PREVENTION** **L T P C**

3 0 0 3

OBJECTIVE:

- To provide knowledge on sources and characteristics of industrial pollution, techniques and approaches for minimizing the generation of pollutants.
- Application of physio chemical and biological treatment methods for recovery, reuse and disposal supported with case studies under Indian situations.

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

OUTCOMES:

- Understand the different types of wastes generated in an industry, their environmental regulatory legislations and standards.
- Understand about the quantification and analysis of wastewater treatment, atmospheric dispersion of air pollutants, and air pollution control devices.
- Understand about analysis and quantification of hazardous and nonhazardous solid waste wastes, treatment and disposal

REFERENCES

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

CX5096	MEMBRANE TECHNOLOGIES FOR WATER AND WASTEWATER TREATMENT	L T P C 3 0 0 3

OBJECTIVE

- To make students understand about the principles behind separation systems, membrane processes and systems, membrane bioreactors and pretreatment systems.

UNIT I INTRODUCTION 10

Solid Liquid separation systems-Filtration systems- Theory of Membrane separation – mass Transport Characteristics Cross Flow filtration-Membarne Filtration- Types and choice of membranes, porous, non porous, symmetric and assymmetric – Plate and Frame, spiral wound and hollow fibre membranes – Liquid Membranes

UNIT II MEMBRANE PROCESSES AND SYSTEMS 10

Microfiltration – Ultrafiltration- Nano Filtration – Reverse Osmosis – Electro dialysis- Pervaporation -Membrane manufactures – Membrane Module/Element designs – Membrane System components – Design of Membrane systems - pump types and Pump selection – Plant operations – Economics of Membrane systems

UNIT III MEMBRANE BIOREACTORS 9

Introduction and Historical Perspective of MBRs, Biotreatment Fundamentals, Biomass Separation MBR Principles, Fouling and Fouling Control, MBR Design Principles, Design Assignment, Alternative MBR Configurations, Commercial Technologies, Case Studies

UNIT IV PRETREATMENT SYSTEMS 8

Membrane Fouling – Pretreatment methods and strategies – monitoring of Pretreatment – Langlier Index, Silt Density Index, Chemical cleaning, Biofoulant control

UNIT V CASE STUDIES 8

Case studies on the design of membrane based water and wastewater treatment systems – zero Liquid effluent discharge Plants

TOTAL: 45 PERIODS

OUTCOMES:

- Students will be able to apply various transport models for the calculation of membrane fluxes and the extent of separation for various membrane systems
- They will identify the types of experimental data needed for the calculation of membrane parameters.
- They will select a membrane process and design components to carry out a specific separation.
- They will make advancements in membrane techniques to solve environmental problems.

REFERENCES

1. Jorgen Wagner, Membrane Filtration handbook, Practical Tips and Hints, Second Edition, Revision2, Osmonics Inc., 2001

2. K. Yamamoto and Urase T, Membrane Technology in Environmental management, special issue, Water Science and technology, Vol.41, IWA Publishing, 2000
3. Mulder, M., Basic Principle of Membrane Technology, Kluwer Academic Publishers, 1996
4. Noble, R.D. and Stern, S.A., Membrane Separations Technology: Principles and Applications, Elservier, 1995.
5. Symon Jud, MBR Book – Principles and application of MBR in water and wastewater treatment,Elservier, 2006
6. Water Environment Federation (WEF), Membrane Systems for Wastewater Treatment, McGraw-Hill, USA, 2005

ES5005 ATMOSPHERIC SCIENCE L T P C
3 0 0 3

OBJECTIVE:

- To make the students aware of components, thermodynamics and the chemistry of atmosphere.
- To make students understand the Dynamics of atmosphere and problems related to climatic change.

UNIT I INTRODUCTION 9

Introduction: Definitions and terms – A brief survey of atmosphere: Stoichiometry and mass balance, chemical equilibrium, acid-base, optical properties, mass, chemical composition, structure, winds and precipitation. Components of Earth system – Hydrologic cycle – Carbon cycle – Oxygen in earth system – Climate and earth system.

UNIT II ATMOSPHERIC THERMODYNAMICS 9

Atmospheric thermodynamics – The hydrostatic equation – First law of thermodynamics – adiabatic processes – water vapor in air – moisture parameters, latent heats – Normand's rule – Unsaturated air, saturated air – second law of thermodynamics.

UNIT III ATMOSPHERIC CHEMISTRY 9

Composition of tropospheric air – 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 – atmospheric general circulation – numerical weather prediction.

UNIT V CLIMATE 9

The present day climate – Climate variability – Climate equilibrium, sensitivity – Green house warming – Climate changes – 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

OUTCOME:

- The students can able to sought out the problems regarding the change in the atmosphere.
- The students can trouble shoot 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.

ES5006 ENVIRONMENTAL REACTION ENGINEERING L T P C

3 0 0 3

OBJECTIVES:

- To gain the knowledge on the different kinds of reactors for specific reactions.
- To learn the design of different kinds of reactors.

UNIT I **9**

Reaction engineering principles with applications to environmental systems, general reaction mechanisms, Rate Relationships: Concepts and Applications to Homogeneous Systems and Heterogeneous Systems with respect to chemical and biological reactions.

UNIT II **9**

Ideal systems modeling and design, reactor concepts, ideal reactors, reaction rate measurements, Hybrid system modeling and design, Sequencing batch reactor, Reactors in series and reactors with recycle.

UNIT III **9**

Non ideal system modeling and design, non ideal reactor behavior, RTD analysis, PFDR model.

UNIT IV **9**

Reactive interphase mass transfer, Fluid –solid surface reactions, Gas-liquid bulk phase reactions, adsorption in porous solids, Fluid solid processes and gas-liquid processes.

UNIT V **9**

Biological reaction engineering; biological kinetics; enzyme kinetics; Michaelis-Menten equation; simple microbial kinetics; structured kinetic models biological reaction engineering; basic bioreactor concepts; bioreactor modeling; bioreactor operation; batch operation; semicontinuous operation; fed batch operation; continuous operation, and its environmental applications.

TOTAL : 45 PERIODS

OUTCOMES:

- Students will have an ability to analyze reactors and reaction systems.
- They will analyze the reactors and interpret the kinetic data.
- They will have an ability to solve problems of mass transfer with reaction in fluid-solid reactions.
- They will design and sizing of industrial scale reactor on the basis of kinetic data obtained at lab scale

REFERENCES

1. Dunn I.J, Elmar Heinzle, John Ingham, P enosil J.E, 'Biological Reaction Engineering, Wiley inter science, 2005.
2. Martin A. A. and Robert P.H. Reaction Engineering for Pollution Prevention, Elsevier Science B.V., The Netherlands, 2000.
3. Weber, W.J. and Di Giano, F.A., Process Dynamics in Environmental Systems, John Wiley Sons Inc, 1996.

ES5007 ADVANCED OXIDATION PROCESSES AND TECHNOLOGY L T P C

3 0 0 3

OBJECTIVE:

- To make the students aware of the techniques used for removing contaminants using methods such as: Fenton method, photocatalytic oxidation etc.,
- To make students understand advanced oxidation technology to control emissions of pollutants discharged into the environment.

UNIT I **6**

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

UNIT II **9**

Photoinduced AOP, UV Photolysis H_2O_2, UV/O_3 processes, Ozonation, Fenton processes, Ultrasound processes and principles of sonochemistry.

UNIT III **9**

Photochemistry, photolysis, fundamentals of semiconductor photocatalyis, photochemical processes for water and wastewater treatment, photooxidation reactions, photocatalytic reactions, photo-initiated oxidations, heterogeneous and homogeneous photocatalysis and kinetic studies.

UNIT IV **12**

Fenton processes: homo and heterogeneous process, effect of system composition and process, identification of degradation products.

Photoelectrocatalysis process: photooxidation and photomineraliztion of organic matter in water and air: aqueous systems, substrate oxidation and mineralization, comparative studies of photo-initiated AOPs, biodegradability and toxicological studies.

UNIT V **9**

Application of AOPs for VOC reduction and odour treatment, case studies – textile, pharmaceutical and petroleum and petrochemical industries.

TOTAL : 45 PERIODS

OUTCOME:

- After completion of this course, the students can explain the theoretical basis of advanced oxidation techniques used for pollution control
- The students can classify and evaluate the effectiveness of advanced oxidation technology used for pollution control and environmental protection.

REFERENCES

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. Vincenzo Belgiorno, Vincenzo Naddeo and Luigi Rizzo, Water, wastewater and soil treatment by Advanced Oxidation Processes (AOP), Lulu Enterprises, 2011. Harold J.Ratson, Odor and VOC control handbook, Newyork, Mcgraw-hill, 1998.

ES5008 **POLLUTION ABATEMENT** **L T P C**

3 0 0 3

OBJECTIVES:

- To learn the different kinds of pollution and its controlling measures.
- To learn the qualitative analysis and treatment of different kinds of pollution.
- To understand the important issues in pollution control measures and pertinent to environmental legislations.

UNIT I **9**

Man and environment, types of pollution, pollution controls aspects, industrial pollution, pollution monitoring and analysis of pollutants, Indian pollution regulations.

UNIT II **9**

Water pollution- source of water pollution- measurement of quality- BOD- COD- colour and odor-PH- heavy metals-treatments etc (qualitatively). Industrial waste water treatment (qualitatively) and recycle.

UNIT III **9**

Solid wastes- quantities and characterizations – industrial –hazardous waste- radio active waste- simple treatments and disposal techniques (qualitatively treatment).

UNIT IV **9**

Air pollution-types and sources of gaseous pollutants-particulate matter-hazardous air pollutants-global and atmospheric climatic change (Green house effect)-acid rain. Industrial exhaust –characterization and Methods of decreasing the pollutants content in exhaust gasses (qualitatively).

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

OUTCOMES:

- Understand the different types of wastes being generated from the different industries and their environmental regulatory legislations and standards.
- Understand the different types of pollution control techniques.
- Understand the proper disposal of different kinds of pollutants after the treatment.

REFERENCES

1. Jeffrey Pierce J, Environmental pollution and control, Butterworth-Heinemann; 4th edn, 1997
2. Rao. C.S. Environmental Pollution Control Engineering, New age International Publishers, 2006.

CX5079 ENVIRONMENTAL NANOTECHNOLOGY L T P C

3 0 0 3

OBJECTIVES

- To make students understand the principles behind synthesis and fabrication of nanomaterials, their characteristics, features and environmental applications.

UNIT I GENERAL **9**

Background of nanotechnology, particle size and surface area, quantum dot. Converging science and technology, nanotechnology as a tool for sustainability, health, safety and environmental issues.

UNIT II SYNTHESIS AND FABRICATION OF NANOMATERIALS **9**

Preparation of nano scale metal oxides, metals, CNT, functionalized nano porous adsorbents, nano composite- Chemical vapour deposition, sol gel, sonochemical, microwave, solvothermal, plasma, pulsed laser abalation, magnetron sputtering, electrospinning, Molecular imoring.

UNIT III CHARACTERISATION OF NANOMATERIALS **9**

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

UNIT IV OTHER FEATURES OF NANO PARTICLES **9**

Nanoparticle transport, aggregation & deposition. Energy applications-H2 storage.

UNIT V ENVIRONMENTAL APPLICATIONS 9

Gas sensors, microfludics and lab on chip, catalytic and photocatalyic applications, Nonmaterials for ground water remediation, nanomaterials as adsorbents, membraneprocess.

TOTAL : 45 PERIODS

OUTCOME

- Students will be in a position to use
- Nanostructured catalysts such as TiO_2 nanoparticles for water purification.
- Nanoparticles for treatment of chlorinated organic contaminants.
- Nanoparticles for treatment of arsenic, environmental risks of nanomaterials

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, Jeo Yues Bolteru, 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.

ES5009 BIOTECHNOLOGY IN ENVIRONMENTAL APPLICATIONS L T P C

3 0 0 3

OBJECTIVES:

- 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 5

Principles and concepts of environmental biotechnology - usefulness to mankind.

UNIT II 11

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 and applications in agriculture- role of extra cellular polymers.

UNIT III 11

Biotechnological remedies for environmental damages - decontamination of ground water systems – subsurface environment - reclamation concepts - bioremediation. Production of proteins - biofertilizers. Biodegradation of solid wastes - physical, chemical and microbiological factors of composting - health risk - pathogens – odor management - technologies of commercial importance advances in biogas technology - case study.

UNIT IV **9**

Concept of DNA technology - plasmid - cloning of DNA - mutation - construction of microbial strains.

UNIT V **9**

Environmental effects and ethics of microbial technology - safety of genetically engineered organisms.

TOTAL : 45 PERIODS

OUTCOMES:

- Students will be able to differentiate between different environmental pollutants.
- Distinguish between different pollutants and identify the appropriate waste treatment to the relevant problem

REFERENCES

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

ES5010 **SOIL POLLUTION ENGINEERING** **L T P C**
3 0 0 3

OBJECTIVES:

- To learn the characteristics of the soil and to learn the contaminants transport in the soil
- To learn the soil pollution controlling techniques.

UNIT I PHYSICS AND CHEMISTRY OF SOIL **8**

Soil formation – composition – soil fabric – mass-volume relationship – Index properties 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 soilpollutant interaction.

UNIT II INORGANIC AND ORGANIC GEOCHEMISTRY **9**

Inorganic geochemistry – Metal contamination – 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 9

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

UNIT IV GROUND IMPROVEMENT TECHNIQUES IN WASTE MANAGEMENT 9

Role of Ground Improvement-Drainage and Ground Water Lowering-Electro osmotic Methods-Diaphragm walls-Thermal and Freezing methods - Insitu Densification – Deep Compaction - Dynamic Compaction -Blasting Sand piles pre-loading with sand drains- Stone Columns Lime piles- Earth reinforcement -rock bolts Cables and guniting Geotextiles as reinforcement Filtration. Drainage and Erosion control.

UNIT V SOIL REMEDIATION TECHNOLOGIES 10

Contaminated site characterization – Containment – Soil vapour extraction - Soil washing – Solidification and Stabilization – Electro-kinetic remediation – Thermal desorption Vitrification – In-situ and Ex-situ Bioremediation – Phytoremediation – Soil fracturing –Biostimulation – Bioaugmentation –Chemical oxidation and reduction.

TOTAL : 45 PERIODS

OUTCOMES:

- Understand the nature of the soil and its characteristics.
- Analyze the different contaminant transport mechanisms in the soil systems.
- Understand the different kinds of soil remediation techniques.

REFERENCES

1. Calvin Rose, An Introduction to the Environmental Physics of Soil, Water and Water Sheds, Cambridge University Press, 2004.
2. Hari D. Sharma and Krishna R. Reddy, Geo-Environmental Engineering : Site Remediation, Water Contaminant and Emerging Water Management Technologies, John Wiley & Sons Limited, 2004.
3. Marcel Vander Perk, Soil and Water Contamination from Molecular to Catchment Scale, Taylor & Francis, 2006.
4. Paul Nathanail C. and Paul Bardos R., Reclamation of Contaminated Land, John Wiley & Sons Limited, 2004.
5. William J. Deutsch, Groundwater Geochemistry: Fundamentals and Applications to Contamination, Lewis Publishers, 1997

CX5095 ENVIRONMENT, HEALTH AND SAFETY IN INDUSTRIES L T P C

3 0 0 3

OBJECTIVE

- To make students to get a clear picture of environment, health and safety systems, their features and techniques used and the principles and methods of effective training.

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 organisation 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

OUTCOME

- On completion of the course, the students are expected to be familiar with accident prevention techniques, hazard analysis techniques and legislations pertaining to safety in chemical industries.

REFERENCES

1. Effective Environmental, Health, and Safety Management Using the Team Approach by Bill Taylor, Culinary and Hospitality Industry Publications Services2005
2. Environmental and Health and Safety Management by Nicholas P. Cheremisinoff and Madelyn L. Graffia, William Andrew Inc. NY, 1995

3. The Facility Manager's Guide to Environmental Health and Safety by Brian Gallant, Government Inst Publ., 2007.

ES5011 REMOTE SENSING AND GIS APPLICATIONS IN ENVIRONMENTAL MANAGEMENT **L T P C**
3 0 0 3

OBJECTIVE

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

UNIT I OVERVIEW OF REMOTE SENSING **5**

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 **11**

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 **11**

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

UNIT IV GEOGRAPHICAL INFORMATION SYSTEM **6**

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 **12**

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

TOTAL : 45 PERIODS

OUTCOME

- The students will apply remote sensing and GIS to solve problems pertaining to environmental engineering.

REFERENCES

1. Burrough, P.A. and McDonnell, R.A., Principles of Geographic Information systems Oxford University Press, New York, 2001.
2. GolfriedKonechy, Geoinformation: Remote sensing, Photogrammetry and Geographical Information Systems, CRC press, 1st Edition, 2002.

3. Lillesand, T.M. and Kiefer, R.W, Remote sensing and image interpretation, John Wiley and sons, New York, 2004.
4. Lintz, J. and Simonet, Remote sensing of Environment, Addison Wesley Publishing Company, New Jersey, 1998.
5. Pmapler and Applications of Imaging RADAR, Manual of Remote Sensing, Vol.2, ASPR, 2001.

CX5092 **ENERGY MANAGEMENT** **L T P C**
3 0 0 3

OBJECTIVES

- Students gain the knowledge on energy sources, various forms, demand, power requirements, conservation and optimization techniques and the sources of continuous power.

UNIT I **9**

Energy sources; coal oil, natural gas; nuclear energy; hydro electricity, other fossil fuels; geothermal; supply and demand; depletion of resources; need for conservation; uncertainties; national and international issues.

UNIT II **9**

Forecasting techniques, energy demand, magnitude and pattern, input and output analysis, energy modeling and optimal mix of energy sources. Energy - various forms, energy storage, structural properties of environment.

UNIT III **9**

Bio-geo-chemical cycles; society and environment population and technology. Energy and evolution, growth and change, patterns of consumption in developing and advances countries, commercial generation of power requirements and benefit.

UNIT IV **9**

Chemical industries, classification, conservation in unit operation such as separation, cooling tower,drying, conservation applied to refineries, petrochemical, fertilizers, cement, pulp and paper, food industries, chloro alkali industries, conservation using optimization techniques.

UNIT V **9**

Sources of continuous power, wind and water, geothermal, tidal and solar power, MHD, fuel cells, hydrogen as fuel. Cost analysis, capacity; production rate, system rate, system cost analysis, corporate models, production analysis and production using fuel inventories, input-output analysis, economics, tariffs.

TOTAL: 45 PERIODS

OUTCOME

- The students will be in a position to develop energy efficient process
- Students will focus on the conservation of energy while developing industrial processes

REFERENCES

1. Gramlay, G. M., Energy , Macmillan Publishing Co., New York, 1975.
2. Krentz, J. H., Energy Conservation and Utilisation , Allyn and Bacur Inc., 1976.
3. Loftiness, R.L. – Energy Hand Book, Van Nostrand Reinhold Company, New York, 1978.
4. Rused, C. K., Elements of Energy Conservation , McGraw-Hill Book Co., 1985.

ES5012 CLIMATE CHANGE AND ADAPTATION L T P C
3 0 0 3

OBJECTIVE:

- To understand the Earth's Climate System and the concept of Global Warming.
- To comprehend the impact of climate change on society and its mitigation measures.

UNIT I EARTH'S CLIMATE SYSTEM 9

Introduction-Climate in the spotlight - The Earth's Climate Machine – Climate Classification - Global Wind Systems – Trade Winds and the Hadley Cell – The Westerlies - Cloud Formation and Monsoon Rains – Storms and Hurricanes - The Hydrological Cycle – Global Ocean Circulation – El Nino and its Effect - Solar Radiation –The Earth's Natural Green House Effect – Green House Gases and Global Warming – Carbon Cycle.

UNIT II OBSERVED CHANGES AND ITS CAUSES 9

Observation of Climate Change – Changes in patterns of temperature, precipitation and sea level rise – Observed effects of Climate Changes – Patterns of Large Scale Variability – Drivers of Climate Change – Climate Sensitivity and Feedbacks – The Montreal Protocol – UNFCCC – IPCC –Evidences of Changes in Climate and Environment – on a Global Scale and in India – climate change modeling**.**

UNIT III IMPACTS OF CLIMATE CHANGE 9

Impacts of Climate Change on various sectors – Agriculture, Forestry and Ecosystem – Water Resources – Human Health – Industry, Settlement and Society – Methods and Scenarios – Projected Impacts for Different Regions– Uncertainties in the Projected Impacts of Climate Change – Risk of Irreversible Changes.

UNIT IV CLIMATE CHANGE ADAPTATION AND MITIGATION MEASURES 9

Adaptation Strategy/Options in various sectors – Water – Agriculture –- Infrastructure and Settlement including coastal zones – Human Health – Tourism – Transport – Energy – Key Mitigation Technologies and Practices – Energy Supply – Transport – Buildings – Industry – Agriculture – Forestry - Carbon sequestration – Carbon capture and storage (CCS)- Waste (MSW & Bio waste, Biomedical, Industrial waste – International and Regional cooperation.

UNIT V CLEAN TECHNOLOGY AND ENERGY 9

Clean Development Mechanism –Carbon Trading- examples of future Clean Technology – Biodiesel – Natural Compost – Eco- Friendly Plastic – Alternate Energy – Hydrogen – Bio-fuels – Solar Energy – Wind – Hydroelectric Power – Mitigation Efforts in India and Adaptation funding.

TOTAL : 45 PERIODS

OUTCOME:

- The students can understand the concept of climate change and its consequences.
- The students can adopt the methodologies in finding the changes in climate

REFERENCES

1. Al core 'inconvenient truth" – video form
2. Dash Sushil Kumar, "Climate Change – An Indian Perspective", Cambridge University Press India Pvt. Ltd, 2007
3. IPCC Fourth Assessment Report – The AR4 Synthesis Report,
4. Jan C. van Dam, Impacts of "Climate Change and Climate Variability on Hydrological Regimes", Cambridge University Press, 2003

ES5013 WASTE MANAGEMENT AND ENERGY RECOVERY L T P C
3 0 0 3

OBJECTIVE:

- To understand the comprehensive overview of solid and hazardous waste management.
- To gain the knowledge on solid waste management design aspects.
- To learn the energy generation process from the solid waste management units.

UNIT I SOLID WASTE – CHARACTERISTICS AND PERSPECTIVES 6

Definition - types – sources – generation and estimation. Properties: physical, chemical and biological – regulation

UNIT II COLLECTION, TRANSPORTATION AND PROCESSING TECHNIQUES 8

Onsite handling, storage and processing – types of waste collection mechanisms - transfer Stations : types and location – manual component separation - volume reduction : mechanical, thermal – separation : mechanical, magnetic electro mechanical

UNIT III ENERGY GENERATION TECHNIQUES 16

Basics, types, working and typical conversion efficiencies of composting – anaerobic digestion – RDF – combustion – incineration – gasification – pyrolysis

UNIT IV HAZARDOUS WASTE MANAGEMENT 8

Hazardous waste – definition - potential sources - waste sources by industry – impacts – waste control methods – transportation regulations - risk assessment - remediation technologies – Private public paternership – Government initiatives.

UNIT V ULTIMATE DISPOSAL 7

Landfill – classification – site selection parameters – design aspects – Leachate control – environmental monitoring system for Land Fill Gases.

TOTAL: 45 PERIODS

OUTCOMES:

- Understand the solid waste remedial measures and their importance.
- Understand the legislations pertaining to solid waste management.

- Understand the different kinds of energy generation techniques for different kinds of solid wastes.
- Understand the proper disposal methods for the different kinds of solid wastes.

REFERENCES

1. Howard S. Peavyetal, Environmental Engineering, McGraw Hill International Edition, 1985
2. LaGrega, M., et al., Hazardous Waste Management, McGraw-Hill, c. 1200 pp., 2nd ed., 2001.
3. ManojDatta, Waste Disposal in Engineered Landfills, Narosa Publishing House,1997
4. Parker, Colin and Roberts, Energy from Waste – An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985.
5. Stanley E. Manahan. Hazardous Waste Chemistry, Toxicology and Treatment, Lewis Publishers, Chelsea, Michigan, 1990
6. Tchobanoglous, Theisen and Vigil, Integrated Solid Waste Management, 2d Ed.McGraw-Hill, New York, 1993.

ES5092 DESIGN OF EXPERIMENTS L T P C

3 0 0 3

OBJECTIVE:

- To impart basic knowledge on statistical design of experiments.
- To learn about various methods employed for the design of experiments.

UNIT I CONCEPTS AND TERMINOLOGY 5

Review of hypothesis testing – P Value, “t” Vs paired “t” test, simple comparative experiment, planning of experiment – steps. Terminology - factors, levels, variables, Design principles – replication, randomization, blocking, confounding, Analysis of variance, sum of squares, degrees of freedom.

UNIT II SINGLE FACTOR EXPERIMENTS 10

Completely randomized design, Randomized block design, effect of coding the observations, Latin Square design, orthogonal contrasts, comparison of treatment means – Duncan’s multiple range test, Newman- Keuel’s test, Fisher’s LSD test, Tukey’s test.

UNIT III FACTORIAL EXPERIMENTS 10

Main and interaction effects, Rules for sum of squares and expected mean square, two and three factor full factorial design, 2k designs with two and three factors, Yate’s algorithm, practical applications.

UNIT IV SPECIAL EXPERIMENTAL DESIGNS 10

Blocking and confounding in 2k design, nested design, split – plot design, two level fractional factorial design, fitting regression models, introduction to response surface methods- Central composite design.

UNIT V TAGUCHI TECHNIQUES 10

Introduction, Orthogonal designs, data analysis using ANOVA and response graph, parameter design – noise factors, objective functions (S/N ratios), multi-level factor OA designs, applications.

TOTAL : 45 PERIODS

OUTCOME:

- The students will be in a position to solve problems involving many factors.
- Be familiar with statistical tools for environmental applications

REFERENCES

1. Angela M.Dean and Daniel Voss, Design and Analysis of Experiments, Springer texts in Statistics, 2000.
2. Douglus C.Montgomery, Design and Analysis of Experiments, John Wiley & Sons,2005
3. Philip J.Ross, Taguchi Techniques for Quality Engineering, Prentice Hall, 1989.

ES5014 BIO - ENERGY CONSERVATION TECHNIQUES L T P C

3 0 0 3

OBJECTIVES

- To learn the different kinds of feed stocks for energy generation.
- To learn the different kinds of energy conservation techniques.
- To design the different types of system for the preparation of fuels.

UNIT I INTRODUCTION 8

Biomass: types – advantages and drawbacks – Indian scenario – characteristics – carbon neutrality – conversion mechanisms – fuel assessment studies

UNIT II BIOMETHANATION 8

Microbial systems – phases in biogas production – parameters affecting gas production – effect of additives on biogas yield – possible feed stocks. Biogas plants – types – design – constructional details and comparison – biogas appliances – Burner, illumination and power generation – effect on engine performance.

UNIT III COMBUSTION 10

Perfect, complete and incomplete – equivalence ratio – fixed Bed, fluid Bed – fuel and ash handling – steam cost comparison with conventional fuels. Briquetting: types of Briquetting – merits and demerits – feed requirements and preprocessing – advantages - drawbacks

UNIT IV GASIFICATION 10

Types – comparison – application – performance evaluation – economics – dual fuel engines – 100 % Gas Engines – engine characteristics on gas mode – gas cooling and cleaning train.

UNIT V PYROLYSIS AND CARBONIZATION 9

Types – process governing parameters – thermo gravimetric analysis – differential thermal analysis – differential scanning calorimetry – Typical yield rates.

TOTAL: 45 PERIODS

OUTCOMES:

- Understand the available feed stocks to prepare the different quality of fuels.
- Understand to develop energy efficient systems.
- Focussed on the conservation of energy while developing industrial processes.

REFERENCES

1. Best Practises Manual for Biomass Briquetting, I R E D A, 1997
2. David Boyles, Bio Energy Technology Thermodynamics and costs, Ellis HoknoodChichester, 1984.
3. Eriksson S. and M. Prior, The briquetting of Agricultural wastes for fuel, FAO Energy and Environment paper, 1990
4. Iyer PVR et al, Thermochemical Characterization of Biomass, M N E S
5. Khandelwal KC, Mahdi SS, Biogas Technology – A Practical Handbook, Tata McGraw Hill, 1986
6. Mahaeswari, R.C. Bio Energy for Rural Energisation, Concepts Publication,1997
7. Tom B Reed, Biomass Gasification – Principles and Technology, Noyce Data Corporation, 1981

CX5080 OPERATIONS RESEARCH L T P C
3 0 0 3

OBJECTIVE

- To learn various methods of solving engineering problems using mathematical tools.

UNIT I MATHEMATICAL PROGRAMMING 12

Introduction, Linear Programming, Solution by simplex method, Duality, Sensitivity analysis, Dual simplex method, Integer Programming, Branch and bound method, Geometric programming and its application.

UNIT II DYNAMIC PROGRAMMING 10

Elements of DP models, Bellman's optimality criteria, Recursion formula, Solution of multistage decision problem by DP method. Application is Heat Exchange Extraction systems.

UNIT III PERT, CPM and GERT 9

Network representation of projects, Critical path calculation, construction of the timechart and resource leveling, Probability and cost consideration in project scheduling, Project control. Graphical Evaluation and Review Techniques.

UNIT IV ELEMENTS OF QUEUING THEORY 7

Basic elements of the Queuing model, M/M/1 and M/M/C Queues.

UNIT V ELEMENTS OF RELIABILITY THEORY 7

General failure distribution, for components, Exponential failure distributions, General model, Maintained and Non-maintained systems, Safety Analysis.

TOTAL: 45 PERIODS

OUTCOMES:

- Understand the mathematical tools that are needed to solve optimization problems.
- Understand to use mathematical softwares to solve the proposed models.
- Understand to identify and develop operation research models for the real systems and to solve it.

REFERENCES

1. Carter, M. W. and Price, C. C., Operations Research: A Practical Introduction Contributor, CRC Press, 2001.
2. Edgar, T. F., Himmelblau, D. M. and Ladson, L. S., "Optimization of Chemical Processes", 2nd Ed., McGraw Hill, New York, 2003.
3. Hillier, F. S., and Lieberman, G. J., Introduction to Operations Research, McGraw- Hill, 2005
4. Taha, H. A., "Operations Research, An introduction", 6th Ed., Prentice Hall of India, New Delhi, 2006.

CX5081 INTELLECTUAL PROPERTY RIGHTS L T P C
3 0 0 3

OBJECTIVES

- After completing the course, the students will have capacity to solve, on their own hand, minor juridical questions within "Intellectual Property Rights". They will also be able to follow and understand more complex juridical discussions.

UNIT I **5**

Introduction – Invention and Creativity – Intellectual Property (IP) – Importance – Protection of IPR – Basic types of property (i). Movable Property ii. Immovable Property and iii. Intellectual Property.

UNIT II **10**

IP – Patents – Copyrights and related rights – Trade Marks and rights arising from Trademark registration – Definitions – Industrial Designs and Integrated circuits – Protection of Geographical Indications at national and International levels – Application Procedures..

UNIT III **10**

International convention relating to Intellectual Property – Establishment of WIPO – Mission and Activities – History – General Agreement on Trade and Tariff (GATT).

UNIT IV **10**

Indian Position Vs WTO and Strategies – Indian IPR legislations – commitments to WTO-Patent Ordinance and the Bill – Draft of a national Intellectual Property Policy – Present against unfair competition.

UNIT V **10**

Case Studies on – Patents (Basumati rice, turmeric, Neem, etc.) – Copyright and related rights – Trade Marks – Industrial design and Integrated circuits – Geographic indications – Protection against unfair competition.

TOTAL: 45 PERIDOS

OUTCOMES:

- After completing the course, the students will have capacity to solve, on their own hand, minor juridical questions within "Intellectual Property Rights". They will also be able to follow and understand more complex juridical discussions.

REFERENCES

1. Eli Whitney, United States Patent Number: 72X, Cotton Gin, March 14, 1794.
2. Intellectual Property Today: Volume 8, No. 5, May 2001, [www.iptoday.com].
3. Subbaram N.R. "Handbook of Indian Patent Law and Practice ", S. Viswanathan, Printers and Publishers Pvt. Ltd., 1998.
4. Using the Internet for non-patent prior art searches, Derwent IP Matters, July 2000.

CX5094 **HYDROGEN AND FUEL CELLS** **L T P C**

3 0 0 3

OBJECTIVES

- Different types of fuel cells and their applications would be studied. Hydrogen production techniques, storage and applications would be studied.

UNIT I HYDROGEN – BASICS AND PRODUCTION TECHNIQUES 9

Hydrogen – physical and chemical properties, salient characteristics. Production of hydrogen – steam reforming – water electrolysis – gasification and woody biomass conversion – biological hydrogen production – photo dissociation – direct thermal or catalytic splitting of water.

UNIT II HYDROGEN STORAGE AND APPLICATIONS 9

Hydrogen storage options – compressed gas – liquid hydrogen – Hydride – chemical Storage – comparisons. Hydrogen transmission systems. Applications of Hydrogen.

UNIT III FUEL CELLS 9

History – principle – working – thermodynamics and kinetics of fuel cell process – performance evaluation of fuel cell – comparison on battery Vs fuel cell

UNIT IV FUEL CELL – TYPES 9

Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerits

UNIT V APPLICATION OF FUEL CELL AND ECONOMICS 9

Fuel cell usage for domestic power systems, large scale power generation, Automobile, Space. Economic and environmental analysis on usage of Hydrogen and Fuel cell. Future trends in fuel cells.

TOTAL: 45 PERIODS

OUTCOMES:

After completing the course, student should have learnt

- Basics and working principles of the Fuel cell technology.
- Selection the suitable materials for electrode, catalyst, membrane for the fuel cells.
- The mass transfer process such as pressure drop an d velocity distribution in single cell as well as stack.
- Design and stack making process for real field applications

REFERENCES

1. Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma (2005)
2. Bent Sorensen (Sørensen), Hydrogen and Fuel Cells: Emerging Technologies and Applications, Elsevier, UK (2005)
3. Kordesch, K and G.Simader, Fuel Cell and Their Applications, Wiley-Vch, Germany (1996).
4. Hart, A.B and G.J.Womack, Fuel Cells: Theory and Application, Prentice Hall, NewYork Ltd., London (1989)
5. Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA (2002).
6. Viswanathan, B and M AuliceScibioh, Fuel Cells – Principles and Applications, Universities Press (2006)

PP5391 CORROSION ENGINEERING L T P C

3 0 0 3

OBJECTIVES

- To impart knowledge on corrosion in petroleum refining.

UNIT I TYPES OF CORROSION AND TESTING METHODS 9

Basic principles of corrosion and its control – Forms of corrosion, uniform, Galvanic, Crevis, pitting, selective leaching, erosion, stress-corrosion, cracking – Cavitation phenomena & their effects – Corrosion testing – Field testing – Electrochemical techniques for measurement of corrosion rates, corrosion detection and components examination – Accelerated salt-spray testing.

UNIT II CORROSION PROTECTION METHODS 9

Corrosion inhibitors, electroplated coatings, conversion coatings, anodizing, hot dipping, spray metal coatings, zinc coating by alloying, electrophoteric coatings and electro painting, powder coating, electrical methods of corrosion protection, composite materials in corrosion minimization – Cathodic and Anodic protections.

UNIT III CORROSION IN SPECIFIC ENVIRONMENTS 9

Corrosion damage to concrete in industrial and marine environments and its protection; biological corrosion, halogen corrosion of metals, environmental degradation of materials, corrosion and inspection managements in chemical processing and petrochemical industries.

UNIT IV CORROSION IN SPECIFIC CASES AND CONTROL 12

Corrosion in structure – corrosion of stainless steels – corrosion in power equipments, corrosion in electrical and electronic industry – corrosion and selection of materials of pulp and paper plants – corrosion aspects in nuclear power plants – corrosion of surgical implants and prosthetic devices.

UNIT V CORROSION AND COUNTRY'S ECONOMY 6

Corrosion protection management–process maintenance procedures under corrosion Environments

TOTAL : 45 PERIODS

OUTCOMES

- Students learn about the types of corrosion, protection methods, corrosion in specific environments, corrosion in specific cases and control.

REFERENCE

1. Fontana, M.G., "Corrosion Engineering", Edn 3, McGraw Hill, 1989
2. Roberge, P.R., Handbook of Corrosion Engineering, McGraw-Hill,2000

CX5083 GREEN CHEMISTRY AND ENGINEERING L T P C

3 0 0 3

OBJECTIVE

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

UNIT I 9

Overview of Major Environmental Issues, Global Environmental Issues. Air Quality Issues. Water Quality Issues, Ecology, Natural Resources, Description of Risk. Value of Risk Assessment in the Engineering Profession. Risk-Based Environmental Law. Risk Assessment Concepts. Hazard Assessment. Dose-Response. Risk Characterization.

UNIT II 9

Pollution Prevention- Pollution Prevention Concepts and Terminology. 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 III 9

Green Chemistry. Green Chemistry Methodologies. Quantitative/Optimization-Based Frameworks for the Design of Green Chemical Synthesis Pathways. Green Chemistry Pollution Prevention in Material Selection for Unit Operations. Pollution Prevention for Chemical Reactors. Pollution Prevention for Separation Devices. Pollution Prevention Applications for Separative Reactors. Pollution Prevention in Storage Tanks and Fugitive Sources.

UNIT IV **9**

Process Energy Integration. Process Mass Integration. Case Study of a Process Flow sheet- Estimation of Environmental Fates of Emissions and Wastes.

UNIT V **9**

Magnitudes of Environmental Costs. A Framework for Evaluating Environmental Costs. Hidden Environmental Costs. Liability Costs. Internal Intangible Costs. External Intangible Costs. Introduction to Product Life Cycle Concepts. Life-Cycle Assessment. Life-Cycle Impact Assessments. Streamlined Life-Cycle Assessments. Uses of Life- Cycle Studies.

TOTAL: 45 PERIODS

OUTCOMES

- Upon completion of this course, the students would understand the fundamentals of green chemistry and engineering
- Application of these principles during the design, retrofit and management of chemical processes for a more sustainable chemical manufacturing

REFERENCES

1. Allen, D.T., Shonnard, D.R, Green Engineering: Environmentally Conscious Design of Chemical Processes. Prentice Hall PTR 2002.
2. MukeshDoble and Anil Kumar Kruthiventi, Green Chemistry and Engineering, Elsevier, Burlington, USA, 2007.